United States
Department of
Agriculture
in cooperation
with Southern DA's,
AES and CES

Animal and Plant
Health Inspection Service

APHIS 81-33

Appendix C

Environmental Evaluation

Beltwide Boll Weevil/Cotton Insect Management Programs

PREFACE

This report was prepared by the Environmental Evaluation Team (ENET) to satisfy the requirements for the environmental evaluation of the Boll Weevil Control Trial Strategies and Beltwide Boll Weevil/Cotton Insect Management Programs. The ENET activities were carried out concurrently over the past 3 years with the Biological Evaluation Team (BET) and the Economic Evaluation Team (EET).

The Animal and Plant Health Inspection Service (APHIS), through its Environmental Evaluation Staff (EES), was responsible for the environmental evaluation of the trials and beltwide programs, aided by State cooperators in Mississippi and North Carolina. The analysis itself was provided under contract by Ketron, Inc., Arlington, Virginia.

Collectively, the ENET, BET, and EET reports comprise the findings and recommendations reflected in the Overall Evaluation Team (OET) report to the Secretary of Agriculture.

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EXECUTIVE SUMMARY

This report is the product of the Environmental Evaluation Team's (ENET) evaluation of the boll weevil control trial areas and an environmental risk/ hazard environmental evaluation of the Beltwide Boll Weevil/Cotton Insect Management Programs. The report presents the results of an evaluation of three major control program alternatives: continuation of current practices (CIC), optimum pest management (OPM), and boll weevil eradication (BWE). The latter two are designated OPM-I and OPM-BWE, respectively, for the beltwide evaluation.

The ENET evaluation effort was comprised of six major activities. The first was an understanding of legal, administrative, regulatory, enforcement, procedural, and substantive requirements for an environmental evaluative process. The second was the consideration of the boll weevil control trial areas and the environmental setting where projected beltwide programs would take place throughout the cotton production area. The environmental setting determines where the impacts may occur and permits the selection of variables which characterize the environment to be analyzed. The third activity was local impact assessment and prediction where variables were evaluated, interpreted, and impact predicted. The fourth activity was the aggregation of measurements of effect on each selected evaluation area. Based on this aggregation of effect, relative indices were calculated which reflected an evaluation of a control strategy's environmental impact. The fifth activity involved the procedures, methodologies, and findings of a quantitative analysis of large areas, i.e., Cotton Belt. The sixth and final activity involved the preparation of a meaningful analysis as a decision aid in choosing among a

limited set of large scale technological alternatives with low probability, high consequence environmental aspects.

The ENET's evaluation effort should meet the concern that agencies conduct their programs in ways which protect the Nation's ecological, cultural, and historic heritage as embodied in the intent of statutes, regulations, Executive Orders, and Secretary Memoranda on the subject. This evaluation embodies the recognition that the logic of control decisions must be based on very sound knowledge of (1) the crop protection chemicals and their potential hazard, (2) the patterns of transport throughout the environment and consequent exposure levels, (3) the effects of these calculated exposure levels upon biotic and abiotic interactions, and (4) the risk of these interactions upon sensitive environmental areas. The following presents the technical evaluation of the trial strategies and beltwide programs within the context of these four considerations.

The BOLL-1 model used by the ENET for the trial area evaluations considers seven modules or areas of risk:

- The Offsite Drift module provides an appraisal of the potential problems stemming from drift of aerially applied pesticides.
- The Human Ingestion module assesses the relative potential for the human ingestion of program-applied pesticides in the study area.
- The Research Conflicts module identifies and evaluates any negative effects of an insect control program on nearby, ongoing research.
- The Fish Farms and Hatcheries module evaluates the potential harmful effects of an insect control program on the commercial fish farms and hatcheries in the study area.

- The Endangered and Threatened Species module provides an evaluation of the potential harmful effects of a program on any endangered or threatened species found in the study area.

- The Wildlife module asesses the quantity of each insecticide and the toxicity of these insecticides to birds and mammals and compares this toxicity data to actual residue sampling data.

- The Aquatics module discusses several factors that influences the degree of risk of the trial strategies to each area's aquatic systems.

Data from the above modules were combined into an overall index of impact for the strategies in the trial areas for each of the three trial years. This overall index, "Q", is technically, the weighted sum of the normalized indices from each of the seven areas of risk. It is an expression of environmental risk with a calculated value between 0 (no effect) and 1,000 (worst case) which reflects the general environmental condition in the trial areas at a specific time. Any value greater than 0 is an expression of impact to the environment from the trial strategy. The following overall indices were calculated for the three trial years:

OVERALL INDICES OF TRIAL STRATEGIES

	Trial Years		
Strategy	1978	1979	1980
Q_{OPM}	257	346	329
Q_{CIC-MS}	37	138	164
Q_{BWE}	160	24	12
Q_{CIC-NC}	219	294	171

The major dimension of impact (factor) in the trials which affected the overall index was the human ingestion index which was directly affected by offsite drift. When the magnitude of pesticide use in a strategy changed (as the result of more or less acres treated), the overall index increased or decreased as reflected in the above table.

These results showed that the BWE strategy after the first year had the lowest overall index of impact in the trial areas. This was primarily due to a reduction in the amount of insecticide which, in turn, lowered the human ingestion index. However, the magnitude of overall indices of all strategies could be considered low when compared to a maximum value of 1,000.

Similarly, the pesticide residue monitoring data gathered from the trial areas by APHIS in 1978, 1979, and 1980 indicated that none of the strategies had a high potential for adverse environmental impact in the trial areas.

The projected Beltwide Boll Weevil/Cotton Insect Management Programs were evaluated, utilizing the Environmental Evaluation of Pesticides (EEP) model. The environmental evaluation consisted of a quantitative detailed analysis (involving pesticide residue transport and distribution modeling) over three selected river basins, the Santee, Flint, and Red. A less detailed analysis (excluding transport and distribution modeling) was conducted over an additional 12 river basins. These 15 river basins were considered by the ENET as representative of river basins across the Cotton Belt. Because of report delivery time constraints, only the results of the detailed analysis are presented in the ENET report. However, the evaluation of the additional 12 river basins revealed no significant changes in the results of the ENET beltwide evaluation. The evaluation of the additional 12 river basins is included as Attachment M.

The EEP methodology uses application information and river basin characteristics data to model the transport and distribution of the insecticides throughout selected river basins. Because of cost and time considerations, the ENET chose only representatives from the following categories of insecticides for their beltwide evaluation: organophosphates (methyl parathion--CIC and OPM, malathion and azinphos-methyl—BWE); carbamates (methomyl—CIC and OPM); synthetic pyrethroids (permethrin--CIC and OPM); and insect growth regulators (diflubenzuron—BWE). Using the residue values of these insecticides, calculated by the transport and distribution methodology, several aspects of environmental risk were evaluated: nontarget agriculture, aquatic life (including fish farms and hatcheries), wildlife, endangered and threatened species, human ingestion, research conflicts, and social perceptions of the program.

In general, the beltwide evaluation revealed only three potential environmental impacts as determined by the conditions of the evaluation. All should be easily mitigatable and, in fact, should not be affected at all if the selected beltwide program is properly administered.

- Because many of the insecticides used in the beltwide programs are highly toxic to bees, bee colonies next to cottonfields could suffer significant losses. Beekeepers must be advised of spray activities to allow them time to remove any hives near cottonfields to a safe distance.

- The habitat for one State-listed threatened species, the beetle species Myotrupes retuses, which could be affected, would need to be mapped to ensure spray operations do not inadvertently spray its habitat (its

habitat is not cottonfields). Similar situations could be expected to occur throughout the Cotton Belt as the status of endangered and threatened species and their critical habitats change.

- Under worst-case conditions, excessive runoff due to heavy rains immediately after insecticide application may result in short-term effects to populations of some small aquatic organisms in farm ponds or small streams immediately adjacent to cottonfields. However, because of the short-lived nature of the insecticides involved, it is expected that any aquatic populations affected would recover rapidly.

The results of the environmental evaluation of each of three candidate beltwide programs (CIC, OPM-I, and OPM-BWE) in selected river basins (Santee, Flint, and Red), showed that there were no predictable major adverse environmental effects expected from any of the three programs. In the event, however, that other insecticides are used, the present results may not be comparable.

The beltwide evaluation of the OPM-BWE program was based on the worst-case condition, i.e, the first year of the program where the highest pesticide use would be expected in any given treatment area. The Economic Evaluation Team (EET) Delphi estimates project that boll weevil insecticides for OPM-BWE are considerably reduced in subsequent years in any given treatment area.

From an environmental risk standpoint, a reduction of pesticide use in a program also reduces the potential risk of adverse effects and maintains the quality of the environment. The benefit of pesticide reduction is that the capacity of the environment to respond to the exposure levels of pesticides has been improved. This implies that any program which reduces its total pesticide load in the environment improves the capacity of the environment to respond to

insecticide pressure and should be a major benefit in terms of human health, aesthetics, recreation, and social cost, for example.

Although the beltwide evaluation indicated that a selected program may not cause significant adverse effects on the environment, the National Environmental Policy Act requires Federal Agencies to avoid or minimize any possible adverse effect of their actions upon the quality of the environment. There are at least 15 other prominent legislative Acts which mandate Federal Agencies to environmental conservation. These Acts address the protection, conservation, rehabilitation, or mitigation of the environmental resources of the Nation.

Any one of these legislative Acts, not to mention State and Federal regulatory actions, could impact the future operability of any program selected for implementation. For example, the Environmental Protection Agency presently contends that permethrin may be carcinogenic. As a result, the ENET recommends that provisions be made to continue the environmental evaluation (not limited to pesticide residue monitoring) should a beltwide program be selected for implementation. Due to the extended time frame for completion of any beltwide program, a long-term environmental evaluation commitment should be made to track the selected program to its completion.

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ATTACHMENTS

A. Environmental Evaluation Plan for Boll Weevil Eradication/ Optimum Cotton Insect Control Program, March 1978.

B. Final Report on the Environmental Evaluation of the 1978 Boll Weevil Control Trial Programs (Revised), KFR 229-79.

C. Final Report on the Environmental Evaluation of the 1979 Boll Weevil Control Trial Programs, KFR 273-80.

D. Final Report on the Environmental Evaluation of the 1980 Boll Weevil Control Trial Programs, KFR 303-81.

E. Guidelines for Environmental Monitoring for Boll Weevil Eradication and Pest Management Trials.

F. Final Report on Initial Efforts Toward a Beltwide Boll Weevil Control Program Environmental Evaluation, KFR 279-80.

G. Interim Report on Beltwide Environmental Evaluation River Basin Modeling, KTR 194-80.

H. Beltwide Boll Weevil/Cotton Insect Management Program Environmental Evaluation: Final Report, KFR 302-81.

I. Three Year Summary of the Boll Weevil Control Trial Programs, KTR 312-81.

J. Residue Monitoring Data, 1978.

K. Residue Monitoring Data, 1979.

L. Residue Monitoring Data, 1980.

M. Supplement to Final Report, Beltwide Evaluation.

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BELTWIDE PROGRAM DEFINITIONS

Final definitions of the beltwide programs were developed and approved by the Cooperative Extension Services (CES) and the Animal and Plant Health Inspection Service (APHIS) in consultation with the Optimum Pest Management Regional Extension Education Advisory Committee, the Overall Evaluation Team, and the Facilitator Group. The beltwide programs were defined as follows:

- Current Insect Control (CIC) assumes insect control as now practiced by producers with a continuation of Extension education and technical assistance at the present level of funding.

- Optimum Pest Management with Continuing Incentives for Boll Weevil Management (OPM-I) would consist of two major insect management options--Optimum Pest Management (OPM) and Modified Pest Management (MOPM)--whichever is most applicable for a particular area. Additional Extension personnel and support would be required to implement both options.

  OPM would utilize the boll weevil/cotton insect management practices that were tested in the Mississippi trial with emphasis on area-wide diapause and/or pinhead square treatments, as needed, and full reimbursement to producers for the cost of these treatments.

  MOPM would be followed in all areas where the area-wide diapause strategy could not be implemented or where it is not needed. It would utilize, if applicable, all of the practices tested in the Mississippi trial except the organized area-wide diapause strategy but may include voluntary diapause treatments by individual producers.

- <u>Optimum Pest Management with Phased Incentives (OPM-PI)</u> includes the same two management options and recommended technical components as OPM-I except that incentive payments for diapause and/or pinhead square treatments of the OPM option are phased out by the fourth year.

- <u>Optimum Pest Management with No-Incentives (OPM-NI)</u> includes the same two management options and technical components of the beltwide program specified for OPM-I except that producers are not reimbursed for diapause or pinhead square treatments of the OPM option.

- <u>Optimum Pest Management with Boll Weevil Eradication (OPM-BWE)</u> includes eradication of the boll weevil as a major component. To insure efficient implementation and to take advantage of the absence of the boll weevil, OPM-NI would be in place prior to, during, and following eradication. Beltwide eradication would utilize technology proven by the North Carolina trial and ongoing research. Eradication would begin in the Southeast and proceed west through eight separate zones, followed by the maintenance of a buffer zone between the United States and Mexico to inhibit reinfestation.

- <u>Current Insect Control with Boll Weevil Eradication (CIC-BWE)</u> would be implemented with present level of funding for Extension education for cotton insect management prior to, during, and following eradication. Beltwide eradication would be the same as OPM-BWE.

LIST OF ACRONYMS

APHHIS	Animal and Plant Health Inspection Service, USDA
BET	Biological Evaluation Team
BOLL-I	Model Used for Environmental Evaluation of Trial Areas
BWE	Boll Weevil Eradication
CIC	Current Insect Control
EEP	Environmental Evaluation of Pesticides, Model Used for Environmental Evaluation of Beltwide Programs
EES	Environmental Evaluation Staff, APHIS, PPQ
EET	Economic Evaluation Team
ENET	Environmental Evaluation Team
E&T	Endangered and Threatened Species
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act, as Amended
MCES	Mississippi Cooperative Extension Service
NAS	National Academy of Science
NMRAL	National Monitoring and Residue Analysis Laboratory, APHIS, PPQ
NRC	National Research Council
OET	Overall Evaluation Team
OPM	Optimum Pest Management
OPM-BWE	Optimum Pest Management with Boll Weevil Eradication

OPM-I .... Optimum Pest Management with Continuing Full Incentive Payments to Producers for Diapause and/or Pin Head Square Treatments.

PESTRA .... Stream Routing Model Used for Beltwide Evaluation

PPQ .... Plant Protection and Quarantine, APHIS

T&D .... Transport and Distribution, Module of EEP Model Used in Beltwide Evaluation

BACKGROUND

THE ENVIRONMENTAL SITUATION

The present environmental concerns of this report go back to the early development of crop protection chemicals and their relationship to wildlife in particular. Rudd and Genelly[1/] documented this concern to provide a summary form of reference data which could be used by wildlife technicians and other interested researchers. The study implied that crop protection chemicals altered the environment and in some cases were not necessarily undesirable.

Because of the controversial nature of the use of pesticides, the National Academy of Sciences (NAS)--National Research Council (NRC) established a committee on Pest Control and Wildlife Relationships in May 1960.[2/] It provided a forum for the discussion of problems of pest control and wildlife relationships.

The controversy over pesticides intensified and the NAS held a symposium[3/] to rewrite the advances in pest control and aid in the understanding of its consequences for man and nature. It was at this symposium that the concern was expanded to balance the need to protect the Nation's supply of food and fiber from the ravages of pests with the maintenance of necessary safeguards to human health and the preservation of a viable environment for plant and animal life.

The U.S. Department of Agriculture (USDA), U.S. Department of the Interior, and the U.S. Department of Health and Human Services cooperated to determine the depths of the scientific questions involved.[4/] The USDA, two years earlier,[5/] undertook to look at pest control by chemical, biological, genetic, and physical means. The subsequent 16 years did not produce satisfactory answers to control pests efficiently without chemicals.

The NAS again tackled the problem in a series on the principles of plant and animal pest control.[6/] The NAS recognized that pest situations increasingly affect man's survival and that the trend will continue. The NAS did not enter the bitter debate precipitated by Rachael Carson's "Silent Spring,"[7/] but did establish principles for control of plant disease, weed control, insects, nematodes, and vertebrate pests.

About the same time, the Mrak Committee published its two part report[8/] on pesticides and their relationship to environmental health and made several recommendations. Many of the recommendations form the basis for the environmental laws, regulations, Executive Orders and Secretarial Memoranda that establish the environmental constraints and mandates affecting the operability of pest control programs.

Environmental evaluation is changing direction and increasing in complexity and costs. In the growth era of environmental concern, the main task lay in predicting levels of pesticide residues in the environment as the result of pesticide use. Rudd and Genelly[1/] questioned the application of crop protection chemicals and predicted serious consequences from their use to wildlife, aesthetics, humans, aquatics, and recreation. At that time, the main task in evaluating the application of crop protection chemicals lay in predicting their toxicity and hazard, primarily in relation to wildlife.

Over the past 24 years, all this has changed with the intervention of new and amended laws and regulations covering practically every area of the environment including the economic and social aspects. For managers of crop protection programs, there is a basic need for more guidance in addressing questions about environmental quality in order to bring it into their decisionmaking process at an early stage.

Regulation of pesticide use is made pursuant to the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended. It mandates the Administrator of the Environmental Protection Agency (EPA) to exercise comprehensive regulatory control over the production, distribution, and use of pesticides. The principle criterion in the FIFRA is to base the pesticide use decision on the assessment of the degree to which the pesticide usage in question would result in "unreasonable adverse effects on the environment." The EPA has given definition to this phrase to mean any unreasonable risk to man and the environment, taking into account the economic, social, and environmental costs and benefits of the use of any pesticide. When a pesticide is registered, EPA contends that it is safe and effective for use in the environment, when used in accordance with its labeling.

Regardless, many other limitations also apply to pest control programs. Since 1967, a series of other acts designed to protect the environment have been passed by Congress. These have had the effect of constraining the use of pesticides and providing a limitation on the types of pest programs which can be considered. Some of these acts are summarized below:

- National Environmental Policy Act (1967) which requires that Federal Agencies take "meaningful consideration" of the "environmental consequences" of their actions,

- Clean Air Act (1967) which provides "emergency powers" to the EPA to immediately restrain any person from emitting substances deemed harmful to the public health,

- Migratory Bird Conservation Act which provides for the establishment of wildlife refuges to protect and conserve migratory birds,

- Water Pollution Control Act (1972) which makes each State responsible for developing "comprehensive pollution control plans for river basins" and requires "best management practices" in these areas,

- Safe Drinking Water Act (1972) which authorizes the EPA to take appropriate action to ensure the safety of public drinking water supplies,

- Endangered Species Act (1973) which requires Federal Agencies to review each activity to determine if it may likely jeopardize species listed as threatened or endangered by the Office of Endangered Species, U.S. Fish and Wildlife Service, Department of the Interior, or the National Marine Fisheries Service, and

- Toxic Substances Control Act (1976) which gives the EPA authority to regulate the manufacture and use of chemicals (other than pesticides and certain other exempted substances) which may present an "unreasonable risk of injury to health or the environment."

In addition, President Carter, in his Environmental Message to Congress, May 1977,[9/] expressed his concern about the use of the environment, particularly where chemicals are introduced into the environment. He requested Federal Agencies to report on their effort to improve the environment. Clearly there was a need for a methodology to promote the logical application of available facts and defensible inferences to meet the requirements of the regulatory environment in which a program of the magnitude of the proposed boll weevil beltwide program would operate.

The Secretary of Agriculture, in a number of Secretarial Memoranda, has expressed concern for the environment and the USDA policy[10/] states that the Department is required to conduct its programs in ways which protect the Nation's ecological, cultural, and historical heritage. This direction embodied the intent of the statutes, regulations, and Executive Orders previously mentioned.

Environmental evaluation itself arose from the recognition that the logic of control decisions themselves must be based on very sound knowledge of (1) the crop protection chemicals and their potential hazard, (2) the patterns of transport throughout the environment and consequent exposure levels, (3) the effects of these calculated exposure levels upon biotic and abiotic interactions, and (4) the risk of these interactions upon sensitive environmental areas.[6/,11/]

PROBLEM STATEMENT

Programs for large area control of pests, such as the beltwide control of the boll weevil, are projects having wide impact on different segments of society. Such programs have a myriad of intricate technical and socio-political details to be resolved involving the biological, economical, and environmental effects of such programs. These projects also have broad consequences, as many different groups in society may be affected to some degree by the actions taken.

These technological projects bring with them potential environmental consequences which raise the possibility of adverse environmental effects, albeit with a low probability of occurrence.[11/,12/] Such technologies thus involve a degree of environmental risk. The following key evaluation problems exist with such projects: (1) multiple, conflicting program

and environmental objectives; (2) significant uncertainties about future events, preferences, and alternatives; and (3) diverse groups whose legitimate interests are often antagonistic and independent of each other. As a result, the evaluation of environmental effects of alternative agriculture pest management programs can be viewed as an extraordinarily complex process and equally as a socio-political problem and a techno-environmental problem.

Environmental decisionmaking involving low probability, yet high consequence occurrences, such as the Beltwide Boll Weevil/Cotton Insect Management Programs has a number of special features relating to measurement of environmental impact, and these are not exhaustive:

- Limited knowledge
- Uncertainty and irreversibility
- Aggregation of preferences
- Distribution of hazards vs. risks
- Counter hazards and risks
- Interregional effects

Environmental impact evaluation in large area agricultural pest control programs involve a number of considerations which differ substantially from what might be described as classical or traditional environmental problems of air and water pollution. For example, uncertainties regarding events and outcomes are somewhat less dynamic in classical pollution problems, such as point source pollution problems. The uncertainty attending environmental situations in nonpoint source use of pesticides is far greater.

Most pest control program managers are risk adverse. Thus, it is necessary to know environmental preference functions (i.e., impact valuations) as well as

the biological and economic outcomes when evaluating technological decisions which entail low probability of high consequence outcomes.

William W. Lowrance defines safety[13/] "...as the judgment of the acceptability of risk, and risk, in turn, as a measure of the probability and severity of harm to human and environmental health." Since this definition is incomplete in the case of environmental evaluation of crop protection programs, the definition has been modified to provide hazard analysis as the basic input into the risk analysis.[14/] In this evaluation, hazard is defined as a measure of the potential of a substance for producing adverse effects to organisms or the environment if that substance is introduced into the organism or the environment. This definition is used to provide a judgmental basis for decisionmaking on environmental safety of the boll weevil beltwide management strategies.

The socio-political process of concern in the context of this study is defined very broadly. It includes the compliance with legislative acts passed by Congress, the regulatory processes established by agencies in implementing these acts, Executive Orders, and Secretarial Memoranda concerning environmental quality and impact analysis, including judicial review of administrative decision processes.

Although many models have been published concerning environmental impact evaluation of pesticide use, these models have tended, for the most part, to be benefit-cost models.[14/-20/] Their use has been designed specifically to identify the most offensive toxicants, mainly for regulation of pesticides, rather than program impact evaluation which is designed to maintain the operability of a pest program in an external regulatory environment, when the pesticide(s) of choice are found to be relatively "safe" when used in accordance with their label.

Further, many of the benefit-cost models have not used a systematic framework within which the adequacy of an environmental assessment model might be examined. The necessity of examination is motivated by the widespread use of models for predicting the environmental consequences of various program activities and by the reliance on these model predictions for deciding whether the particular program complies with various external regulatory requirements.

The National Research Council has stated that pesticide regulatory agencies have not developed a systematic and comprehensive analytical situation that supports their decisions on standard setting and regulatory compliance.[21/] The NRC recommended methods for this type of support as well as for environmental monitoring.[22/] However, these recommendations did not deal with a full spectrum of Federal, State, and local regulatory constraints impacting large scale technological programs such as a Beltwide Boll Weevil/Cotton Insect Management Programs.

The EPA/Food and Drug Administration (FDA)/Consumer Products Safety Commission (CPSC) looked at methods, implications, and perspectives on environmental and health risk assessment.[23/] From that, it appears that in any environmental impact assessment, distinct problems arise within the assessment itself. Secondly, there is a question of how values of impact are determined once the data has been collected. Third is the problem of cost effectiveness, or given that a specific set of funding is available, how the evaluation can be made cost effective in meeting the goals of a program while producing an acceptable assessment.

SCOPE AND PURPOSE

Control of organisms in crops is a complex process especially where pesticides are applied. The pesticides vary in substance, time, rate, and sequence of

application as do their effects vary on the environment. There is a near infinite number of sets of the above conditions. In addition, there is the need to maintain program operability in the light of regulations in which there are no environmental "trade offs," such as endangered species. The overall result is that detailed analysis and evaluation are required to aid in choosing the appropriate risk preference among various pest management strategies available to decision makers.

The Environmental Evaluation Team (ENET) was charged with conducting an indepth environmental evaluation of the Boll Weevil Control Trial Strategies and the Beltwide Boll Weevil/Cotton Insect Management Programs. At the time the boll weevil trials began, the Environmental Evaluation Staff (EES) of Plant Protection and Quarantine (PPQ), Animal and Plant Health Inspection Service (APHIS), was developing two environmental evaluation models to assess the environmental impact of PPQ field programs.

One of the methodologies, the BOLL-1 model,[24/] was developed under a cooperative agreement with the Virginia Polytechnic Institute and State University. The BOLL-1 model was developed to predict the potential environmental impact of pest control programs in relatively small areas. This model was consequently selected by the ENET for evaluating the trial areas.

The BOLL-1 model, although cost effective and relatively precise in small areas, was not suitable for large area environmental evaluation which would be needed for the Beltwide Boll Weevil/Cotton Insect Management Programs. Along with the BOLL-1 model, the EES was developing an Environmental Evaluation of Pesticides (EEP) model.[25/-28/] The EEP model utilized single or multiple river basins as the base evaluative unit(s).

The ENET recognized the complex measurement issues faced given that there are over 250 major river basins, each in excess of 700 square miles, encompassing the Cotton Belt. Since the EEP model was designed to be flexible, particularly with respect to input requirements, and useable across a wide spectrum of pesticides, target areas, and application programs, it was chosen by the ENET as the methodology for the beltwide assessment. It is applicable for either post-operational assessment or forecasting and predicting impact.

The ENET's Environmental Evaluation Plan (Attachment A) required direct and indirect measurements of primary and secondary impact of program control tactics on the environment within the constructs of the program. This plan was formulated to reflect measurements of national, regional, State, and local impact.

The purpose of the ENET evaluation was to assist in coping with environmental risk choices by (a) supplying information and data with regard to the risks under evaluation, and (b) to assure that adequate risk information and data were available from the boll weevil management options of the trial areas and for those boll weevil management options considered for the Cotton Belt.

OBJECTIVES

The ENET had three major objectives:

1. Determine the environmental impact of three boll weevil control tactics in North Carolina and Mississippi during trial period implementation.

2. Evaluate the "beltwide" application of three alternative beltwide programs.

3. Provide for meeting legislative, regulatory, and executive environmental mandates impacting the boll weevil program.

TECHNICAL APPROACH TO ENVIRONMENTAL ASSESSMENT

TRIAL AREA EVALUATION

Introduction

The principle methodology used for the environmental evaluation of the boll weevil trial areas was the BOLL-1 model. This computer assisted evaluative model was designed to assess the potential environmental risks of a pesticide application program in a local area situation. The assessment methodology utilized by the BOLL-1 model considers seven areas of potential environmental impact — offsite drift, human ingestion, research conflicts, endangered and threatened species, wildlife, fish farms and hatcheries, and aquatics —, the calculation of a numerical index for each, and the weighted combination of these into an overall index.

It was necessary to modify and enhance the BOLL-1 model's methodology of calculating these indices, both to compensate for data gaps and to properly address specific characteristics of the program. These changes also simplified the running of the computerized portion of the model.

The model required rather extensive data collection pertaining to such elements as terrain features, wildlife distribution, mechanics of the pesticide application, and food consumption from local sources. Changes to the evaluation methodology reduced the quantity of the data inputs that were necessary, but the model's data storage and processing capabilities were still useful. Data was numerically coded and stored in a sequence of computer files called mapfiles. A mapfile consisted of a blocked collection of cells, where each cell corresponded to a square parcel of land and where a block of 900 (30x30) cells denoted a map. A cell size of 1/3 kilometer (km) per side or

1/9 km^2 (27.4 acres) was used. Individual map files contained data on a single evaluation factor or characteristic such as elevation. Thus, many maps, each located in a separate mapfile, were required to adequately describe a given land area.

Relatively simple algorithms were used to process the data and were designed to aggregate and, where applicable, graphically represent the data to the user in a useful form. The final outputs of the model were a graphical presentation of the aggregated data, a set of indices, one for each of the seven modules, and an overall index, Q, which represented the weighted sum of the seven indices previously calculated.

In general, the model acts as an accounting system and includes very little in the way of program-specific analysis. The bulk of the analysis involved is in formulating the inputs to the model, which then tabulates the various data over the entire study area. This point is discussed in more detail relative to each of the modules to which it is applicable.

Offsite Drift

The purpose of the Offsite Drift module is to provide an appraisal of the problem of drift from aerially applied pesticides. An index of the total number of acres potentially affected by drifting pesticides in each trial area under evaluation is calculated.

The methodology used to calculate this index is primarily based on the average sample field size and the total cotton acreage of each area. Also considered is the frequency with which cottonfields in each area are bordered by other cottonfields.

The first step of the index calculation process is the determination of the average size of each area's sample fields. To estimate drift per field, a field of hypothetical size is created. This field is assumed to have a length equal to twice its width. It is then assumed that significant quantities of pesticide drift equidistantly from this hypothetical field's border for a distance of 30 meters (m). It is understood that spray particles smaller than 50 microns can drift much more than 30 m., but several studies have demonstrated that the quantity actually deposited on the ground decreases sharply after 20-30 m.[29/,30/] Using the previously calculated average field dimensions and this drift distance, an estimate of the average number of acres drifted upon per field is calculated for each area.

Having calculated the number of acres that might be reached by pesticide drifting around the hypothetical field, that portion of surrounding land that contains cotton is estimated and removed, as this is not considered to be nontarget land. The remaining acres are the net number of acres affected by drifting pesticide from a field the size of the average sample field, in each trial area.

To relate this quantity to the entire trial area, the total cotton acreage in each area is divided by the average sample field size to estimate the number of "average" cottonfields in the area. This number is then multiplied by the drift per cottonfield. The resulting number of nontarget acres potentially affected by drifting pesticide is used as the offsite drift index.

Human Ingestion

The Human Ingestion module creates an index of the total potential human ingestion of pesticides in the study area. This is useful for measuring the relative ingestion potentials of alternative programs.

The calculation of the human ingestion index is based on the quantity of pesticide likely to drift to nontarget agricultural land, the number of acres affected by offsite drift, the composition of the agricultural land surrounding the treated fields, and the area-wide production rates for those foods produced on fields surrounding spray areas. All pesticides are treated together to limit the number of variables used in the index. It is understood that neglecting such factors as toxicity and persistence serves to oversimplify the analysis, but EPA label requirements and residue tolerances have been imposed to protect consumers. It is not the intent of this evaluation to estimate pesticide intake for comparison with Acceptable Daily Intakes. The purpose of this analysis is to provide an index useful to compare alternative programs.

The first step of the index calculation is the estimation of the quantity of pesticide drifting to nontarget agricultural land. This is assumed to be 25 percent of the total pesticide applied. This assumption is made if the lack of in-field monitoring does not justify a more elaborate estimation process. The value chosen, 25 percent, is supported by the work done by several researchers.[30/,31/] This pesticide is then apportioned evenly over the nontarget acres, as determined by the Offsite Drift module.

The following factors serve to significantly reduce the quantity of drifting pesticide available to enter the human food chain. Adjacent to each is an estimate of the portion of the quantity that would be lost due to that factor:

- the degradation in the soil of pesticide that lands on the ground, 40%
- the "wash-off" of pesticide from vegetation by wind and rain, 30%

- the degradation of pesticide — microbial, chemical, and photodegradation -- on the plant surface, 50%

- the removal of pesticide attached to the pod or husk of an agricultural product that is discarded at harvest time, and 90%

- the removal of pesticide by food preparation -- peeling, washing, cooking, etc. 30%

When these are combined, the percentage of pesticide that would remain available for intake would be approximately 1.5 percent.* A safety factor of 2x is then introduced and the actual pesticide remaining is 3 percent. This factor is applied to obtain a per-acre "residue" spread evenly over the drift area.

After this quantity of available pesticide has been determined, estimate is made of which crops may contain residues by evaluating which of the crops surrounding the area's cottonfields occur with any frequency. This was accomplished with the aid of aerial photographs of the sample fields. County-wide crop production rates were then obtained for these crops through the State Crop and Livestock Reporting Services. Using the per-acre "residues" in pounds active ingredient (lb. a.i./acre) obtained through estimates of drift, and the production rates (lb. food product/acre) for each crop, individual potential food product residues (lb. a.i./lb. food product) were determined.

To associate these potential food product residues with the components of the typical human diet, diet surveys were consulted to determine average daily

*Calculated as follows:
$(1.0 - 0.4)(1.0 - 0.3)(1.0 - 0.5)(1.0 - 0.9)(1.0 - 0.3)100 = 1.5$ percent

intakes of these products. Using these food product residues and daily food product intake estimates, the potential pesticide intake is calculated. This is expressed in terms of milligrams of active ingredient per kilogram of body weight (mg. a.i./kg. body weight).

Combining this residue and dietary intake data, a daily intake in terms of mg. a.i./kg. body weight (the average person is assumed to weigh 68 kg.) is calculated for each area. These values represent the human ingestion indices for each area.

Research Conflicts

A pesticide application program may affect other programs being conducted within or adjacent to the treatment areas. Some of these programs may involve various types of research. The purpose of the Research Conflicts module is to evaluate any negative effects of a pest control program on nearby ongoing research projects. Impact on research projects may be due to either direct application or drift resulting from the application process. The data analyzed include the proximity of research areas to the treatment area and an assessment of the researcher's estimated impact of the treatment activities.

The BOLL-1 methodology calls for the identification of current research in each trial area. The main sources of such research and related information on other research are usually the nearby land-grant university, agricultural research stations, and related State agencies. Key members of these institutions or agencies were contacted for the identification and evaluation of the projects that may have been disturbed by the program.

After each conflict was identified and its severity discussed with the researcher, a numerical index was calculated. A critical part of this calculation is the determination of the severity of the problem (expressed as

the percentage of the research disrupted). In order to address the problems of both minor disturbances and major disturbances, two indices are calculated for the Research Conflicts module. The value assigned to the first index is the number of severely disrupted projects in the area, i.e., projects for which at least half of the past or current research is disrupted. The second index is defined as the sum of the percentages of disruption of all the affected research projects in the area. In the calculation of the overall index, each index of the Research Conflicts module is compared to a separate threshold. The highest index, relative to its threshold, is used in the calculation.

Data for this module were collected by means of a telephone survey of personnel potentially involved in relevant research in the trial areas. Additional researchers were identified in the course of the data collection. The questionnaire developed for use in this module is contained in Appendix A, KFR 229-79 (Attachment B).

Endangered and Threatened Species

This module provides an evaluation of the potential hazard of a program to any endangered and threatened (E&T) species found in the trial areas. The BOLL-1 model assumes that the existence of an E&T species within close proximity to a treated field represents a potential hazard. In the case of the map cell data storage system, close proximity is usually defined as the same cell or a cell adjacent to one receiving pesticide treatment. The evaluation is based on identifying the overlap of species range with application sites. The U.S. Department of the Interior's national listing and the State's Natural Heritage Program's computerized data bases are utilized to gather information on E&T species sightings.

The first step in the analysis is the identification of each E&T species known to exist within the study area. Ideally, this would be done as critical habitat delineation but, when this is not possible, confirmed records of species' presence in conjunction with known habitat are used. Each map cell in which such an identification is made and which contains a treatment area is assigned a value of one, which is weighted by the severity of the endangerment and the susceptibility of the organism to the pesticide used. Table 1 explains the calculation of the Special Endangerment Factor. For highly mobile species, likely to inhabit and feed over a wider area, the cluster of 24 cells surrounding each data point are used for comparison with the pesticide treatment areas. All cells not containing a confirmed identification are assigned a value of zero. A species is called significantly affected if its endangerment factor is greater than or equal to 0.75.

TABLE 1

SPECIAL ENDANGERMENT FACTORS FOR THE E&T SPECIES INDEX

The species endangerment factor is a product of A and B where

A = 1.0 if the species is listed as endangered,

0.75 if the species is listed as threatened,

0.50 if the species is listed as special concern,

and

B = 1.0 if the species is susceptible to the effects of pesticides,

0.75 if the species is slightly susceptible to the effects of the pesticides,

0.50 if the species has little susceptibility to the pesticides.

Like the preceding Research Conflicts module, the E&T Species module calculates two indices ---one addresses the possibility of a few species being exposed to high hazards and the other addresses the problem of many species being exposed to low hazards. The first index is the total number of species with an endangerment factor of at least 0.75. The second index is obtained by adding together the values of all cells. In the calculation of the overall index, the highest index relative to its threshold is used.

Wildlife

In the Wildlife module, an index of impact was calculated for an insect control program taking place at a given site during a fixed time period. The index involves the comparison of population densities of a selected indicator species at two specific points in time (t and t + 1). In a post application evaluation, this implies population densities before and after the program. In the trial areas, the indicator species selected for use with this evaluation methodology was the whitetail deer (Odocoileus virginianus). While deer graze on cotton infrequently, they may feed on vegetation growing in or adjacent to treated fields.

The module calculates the ratio of hunter-killed deer per square mile in a given county to the number killed per square mile in the State--first prior to the application, then after the application using the following equation:

$$K = \frac{\text{deer kill per mi}^2 \text{ in county}_{t+1} / \text{deer kill per mi}^2 \text{ in State}_{t+1}}{\text{deer kill per mi}^2 \text{ in county}_t / \text{deer kill per mi}^2 \text{ in State}_t}$$

A ratio of less than one indicates a relative decline in the number of hunter-killed deer for an area.

Hunter kill data for white tail deer used to calculate a wildlife index were derived from county and State figures. These data were gathered by means of a mail survey and tag system. Similar calculations could be conducted for other indicator species over the study area if data were available.

The data used to calculate these indices are acknowledged to be less accurate than desired and may vary from year to year. This is due to yearly changes in hunting pressure, changes in the length of the hunting season, and the hunter's willingness to reply to the survey. Although a wildlife index was calculated for each of the first 2 years of the trials, it was later deemed inaccurate for the study by the ENET and was subsequently removed.

Fish Farms and Hatcheries

The purpose of the Fish Farms and Hatcheries module is to evaluate the potential harmful effects of a pest control program on the commercial fish farms and hatcheries in a trial area. The module calculates a numerical index based on the potential harm of insecticide applications made near a fish farm or fish hatchery.

To calculate the numerical fish farms and hatcheries index, each facility was mapped on the BOLL-1 map cell system for comparison with treated fields. Each facility that fell within a cell containing a treated field or adjacent to such a cell was contacted, and the effect determined. An agreement was reached with the facility manager or owner as to the portion of the facility output that had been disturbed, if any. The index was then calculated. As in the case with the Research Conflicts module and the Endangered and Threatened Species module, two indices were calculated for the Fish Farms and Hatcheries module. The first index was the total number of facilities in the area that had suffered at least a 50 percent disturbance of production. The

second index was the sum of the percentages of disruption of all the affected facilities. For the calculation of the overall index, each index of the Fish Farms and Hatcheries module was compared to a separate threshold. The highest index, relative to its threshold, was used as the fish farms and hatcheries contribution to the overall index.

Aquatics

The Aquatics module considers and discusses the potential impact on aquatic biota due to the application of pesticides. Like the wildlife index, the aquatics index is intended to measure changes in selected indicator species.

The Aquatics module is intended to provide an evaluation of the potential adverse impacts that a pest control program might have on the aquatic systems, mainly fisheries, within a trial area. In its original form, the BOLL-1 model includes the methodology needed to calculate a numerical index, based on a comparison of the relative population densities of a selected indicator species at two specific points in time. In theory, this would be calculated similarly to the wildlife index, by comparing the results of creel surveys taken before and after the treatment programs. In the case of the boll weevil trials, aquatic indices were not generated due to the lack of population density data. Instead, a brief review was made of the potential for quantities of pesticide to reach nearby bodies of water and of the toxicity of the different insecticides to fish and other aquatic organisms.

Overall Index

The BOLL-1 model also provides for an overall index, "Q," which is based on the numerical indices of each of the previous modules. "Q" is defined as the

weighted sum of the normalized indices and is calculated according to the following formula:

$$Q = \sum_{i=1}^{n} [x_i / t_i] w_i$$

where:

Q = overall index

i = individual module i

x_i = index of the i^{th} module

t_i = threshold of the i^{th} module

w_i = weight applied to the i^{th} module

The threshold represents the level of hazard which should not be exceeded if the impact is to be judged acceptable. The division of each module's index by its threshold is necessary because the indices are expressed in different units. Dividing by the thresholds serves to normalize, or express in common terms, the indices, forcing them to a unitless value between 0 and 1.

The weights used to calculate "Q" are defined as the relative "importance factors" of the different indices. They represent the perceived importance of each of the areas of potential impact.

"Q" is scaled to fall between 0 (no effect) and 1000 (worst effect).

The thresholds and weights used with the BOLL-1 model were chosen for each trial area using a modified Delphi survey. Members of the scientific community in North Carolina and Mississippi were selected by the ENET and surveyed to gain initial estimates for the thresholds and weights. A second round of the survey was then conducted in which participants were asked to reevaluate their first round estimates in light of the first round results. The second round estimates were used to calculate a refined set of thresholds and weights. This interim set of thresholds and weights was used in the 1978 and 1979

environmental evaluation of the trials.

A third round of the Delphi survey was conducted to further refine estimates of suitable weights and thresholds for use with the BOLL-1 model. In addition, a set of thresholds specific to the CIC-NC trial area was obtained, which was not addressed by the survey's first two rounds. The same participants were used for all three rounds of the survey. One change was made, however, to the method with which the survey was made. At the recommendation of the ENET, all participants were sent copies of the 1979 trial's evaluation to assure that they were aware of both the characteristics of the trials and the means by which the indices were calculated. The results of these surveys are presented in detail in Appendices F and G, KFR 229-79 (Attachment B) and Appendix E, KFR 303-81 (Attachment D).

ENVIRONMENTAL MONITORING FOR PESTICIDE RESIDUES

In addition to the application of the BOLL-1 methodology, the trial areas were monitored during each of the three crop years to measure the pesticide residues throughout the trial period. The objective of the monitoring program was to obtain samples of selected components of the environment such that estimates could be made of the various pesticide residues resulting from program operations. The residues could then provide an additional indication of the impact of the trial strategies on the environment.

Monitoring sites were selected in North Carolina and Mississippi from farms (sites) utilized by the Biological Evaluation Team (BET) for scientific data collection. Fifty such sites were selected within the core area of the BWE trial area in North Carolina and another 50 sites were selected in the OPM trial area of Panola County, Mississippi. Sites, representing CIC areas, were monitored as well in each State. Ten CIC sites were selected in

Pontotoc County, Mississippi, and 10 CIC sites were selected in Cleveland and Gaston Counties, North Carolina.

Guidelines for the monitoring operations were prepared and distributed by the Environmental Evaluation Staff to PPQ field personnel (Attachment E) and remained essentially unchanged for the three crop years. These guidelines specified the collection of soil, water, sediment, and vegetation for each designated site at four time intervals during the year. The guidelines further specified that during a single time interval biological samples (birds, fish, insects, and small mammals) would be collected from sites where possible. A total of approximately 1,300 environmental samples were collected for each of the three crop years. Environmental samples were collected in North Carolina and Mississippi by PPQ field personnel. Analyses of the samples for pesticide residues were carried out by PPQ's National Monitoring and Residue Analysis Laboratory (NMRAL), Gulfport, Mississippi.

BELTWIDE ENVIRONMENTAL EVALUATION

Introduction

At the time the decision was made to evaluate the trial areas prior to choosing a beltwide approach to managing the boll weevil, the Environmental Evaluation Staff of APHIS was developing the EEP model for evaluating the environmental impact of pesticide applications over large areas. The model was composed of nine interrelated modules that collectively could be used in either a predictive or evaluative assessment mode for pesticide residue distribution and environmental effects of pesticides used in the environment. The procedural steps of the model are depicted in Figure 1. A brief description of each module of the EEP model follows.

The river basin was chosen as the large area unit best suited for the EEP model evaluation because of the importance of waterways in transporting

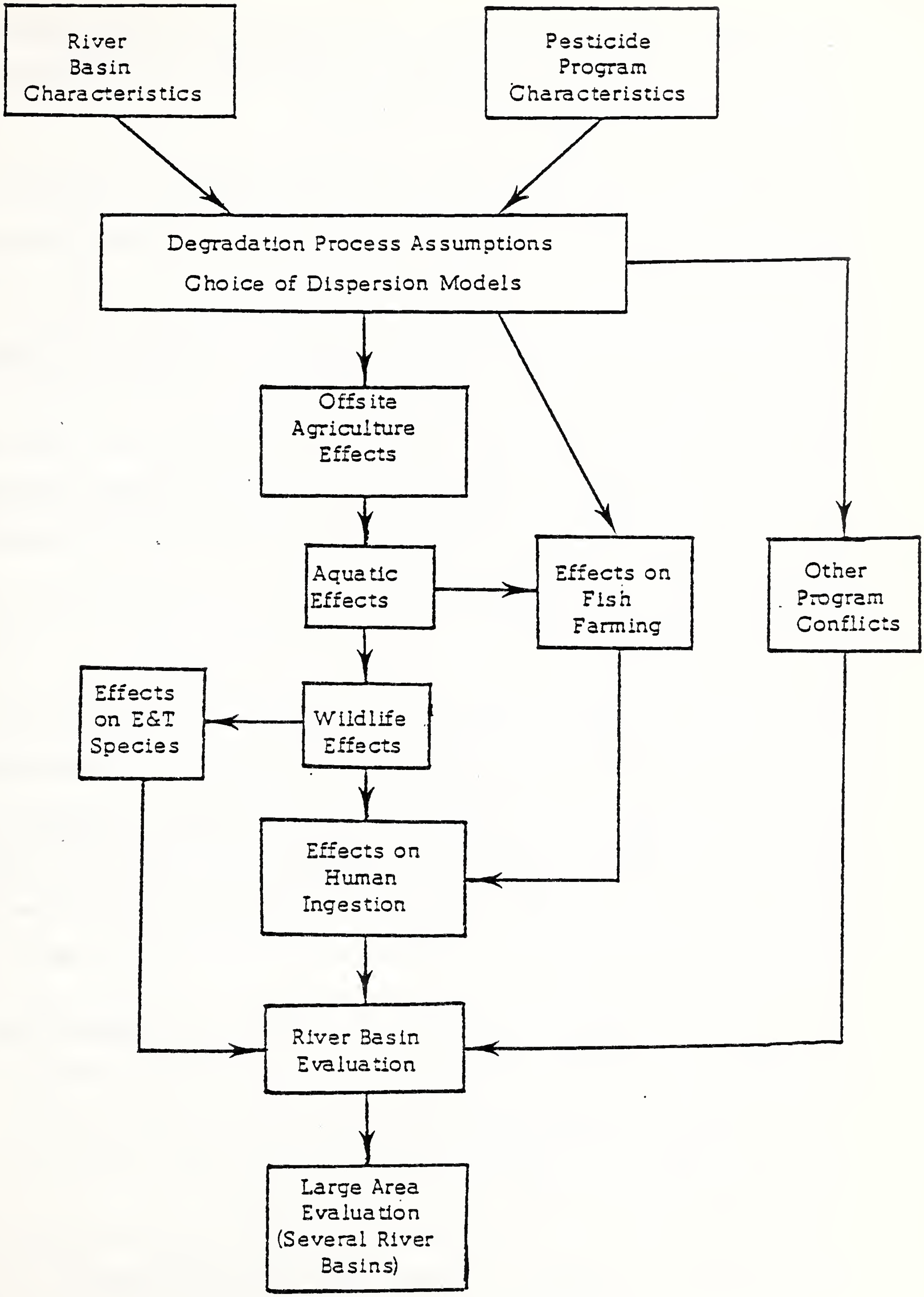


FIGURE 1. MODULE RELATIONSHIPS IN EVALUATION FLOW.

pesticides and because a river basin is a relatively well defined geographic area. Such an evaluation could easily be extended from a single river basin evaluation to a multiple river basin evaluation.

The EEP model was subsequently chosen by the ENET to be used for evaluating the beltwide environmental impact of three boll weevil management strategies (OPM-I, OPM-BWE, and CIC).

Major river basins in excess of 700 square miles were selected for evaluation because smaller basins generally do not provide adequate sources of data required for the EEP methodology. Since there are over 250 major river basins of this size over the Cotton Belt, the first step in the beltwide evaluation process was to choose a representative sample of river basins upon which to conduct the beltwide environmental assessment.

River Basin Selection

Because of time and funding limitations, it was necessary to restrict the number of river basins to be evaluated. The ENET decided that only three river basins would be subjected to full-scale analyses utilizing the EEP model, with less rigorous analyses performed on 12 additional river basins, i.e., water quality modeling was excluded. Details of the selection process can be found in KFR 279-80 (Attachment F).

In the selection process for the three river basins, five principal criteria were used:

- Availability of necessary water modeling data,
- Extent of cotton production in the river basin,
- Existence of unique water systems (estuarine in particular),

- Extent and quality of water monitoring for pesticide residues, and
- Availability of endangered and threatened species information.

The availability of water modeling data, narrowed the list of candidate river basins from approximately 250 to 14 specific basins which best met the modeling requirements of the EEP methodology.

Six of these 14 candidate river basins had no appreciable cotton acreage and thus were eliminated. The remaining eight candidate river basins were then ranked according to the percent of total area planted to cotton.

When considering unique water systems, five of the eight candidate river basins ended in an estuarine system.

The candidate basins were then evaluated relative to each other with respect to availability of pesticide monitoring data.

Finally, those remaining river basins were evaluated relative to one another in terms of endangered species information.

Based upon this selection process, the ENET chose the following three river basins upon which the detailed analyses would be conducted:

- Santee River Basin of EET production subregions 5 and 6 in South Carolina
- Red River Basin of EET production subregions 22 in Louisiana
- Flint River Basin of EET production subregions 7, 8, and 9 in Georgia

The selection process for choosing the additional 12 river basins for the beltwide extrapolation was much less dependent on specific data needs because the type of information needed for the extrapolation analyses was generally

available throughout the United States. Rather, this selection process had to address political, programmatic, and physical concerns by choosing river basins representative of these concerns.

The 12 river basins subsequently chosen for inclusion in the extrapolation sample were:

South Atlantic-Gulf Region

- The main channel of the Cape Fear River Basin of EET production subregions 3 and 4 in North Carolina,
- The Ogeechee River Basin of EET production subregions 7 and 8 in Georgia,
- The Sipsey River Basin of EET production subregion 11 in Alabama.

Lower Mississippi Region

- The Obion River Basin of EET production subregion 12 in Tennessee,
- The Little River Ditches Basin (tributary of the St. Francis River) of EET production subregion 14 in Missouri,
- The White River Basin of EET production subregion 20 in Arkansas,
- The Sunflower River Basin of EET production subregion 17 in Mississippi.

Arkansas-White-Red Region

- The Washita River Basin of EET production subregion 34 in Oklahoma,

- The Wichita River Basin of EET production subregion 29 in Texas,

- The Prairie Dog Town Fork Red River Basin of EET production subregions 29 and 30 in Texas.

Texas-Gulf Region

- The Richland Creek, Chambers Creek, and Cedar Creek Basins (tributaries of the Trinity River) of EET production subregion 28 in Texas,

- The Frio River Basin of EET production subregion 26 in Texas.

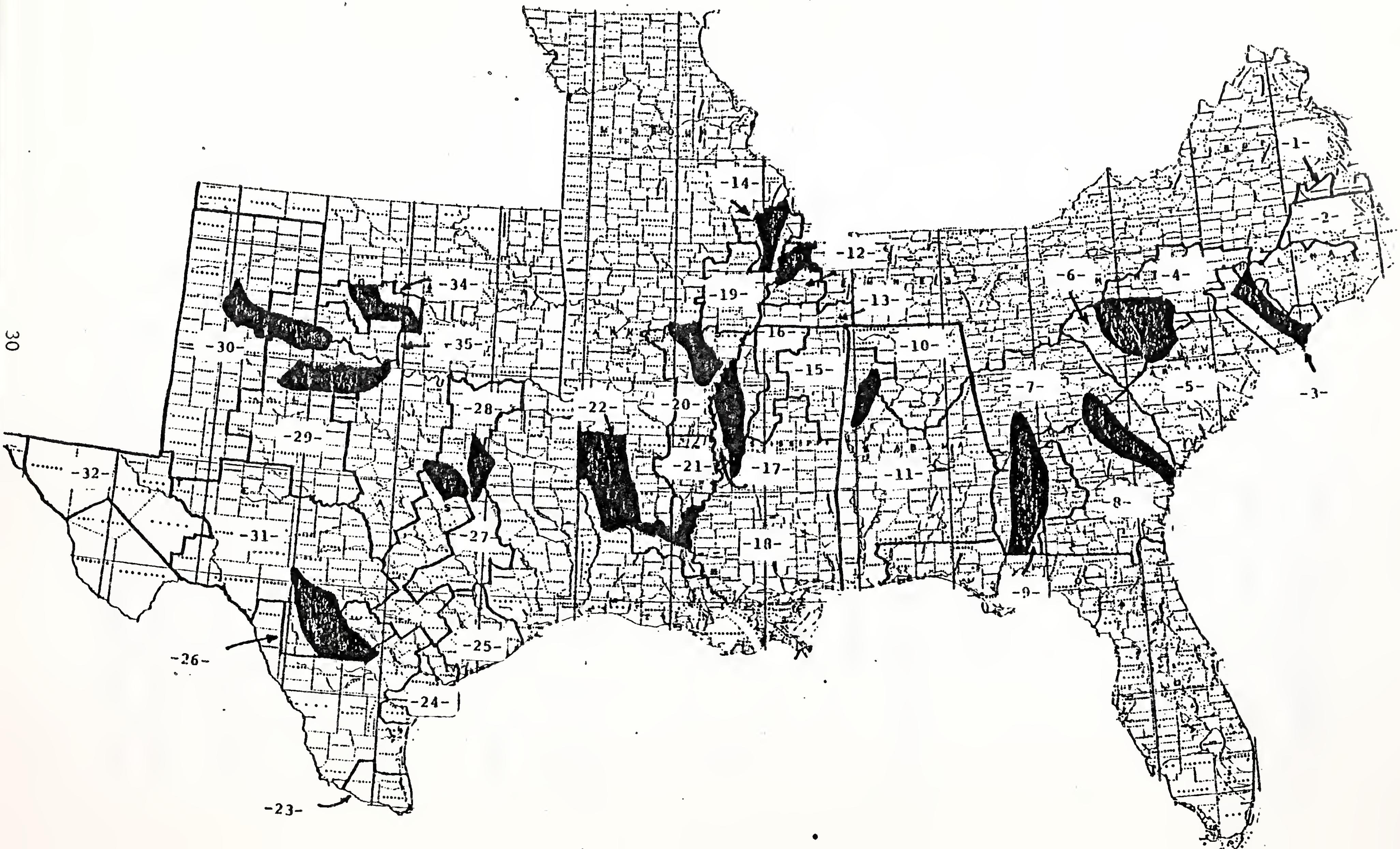
Thus, the beltwide environmental evaluation drew information from 11 States, major portions of 18 EET production subregions, and four significant water regimes across the Cotton Belt. Figure 2 shows the location for each of the 15 selected river basins.

Transport and Distribution

The purpose of the Transport and Distribution module is to estimate time-varying soil and water pesticide residues resulting from pesticide applications, and to predict the extent of induced environmental effects.

Pesticide loadings were calculated for each reach of each modeled river segment based on the assumption that pesticides were carried away from the target

FIGURE 2. LOCATIONS OF THE 15 RIVER BASINS SELECTED.



fields primarily in association with fine soil particles. The amount of soil expected to be lost from the fields was calculated by use of the Universal Soil Loss Equation (USLE) as discussed in KFR 279-80 (Attachment F). The amount of pesticide carried by eroded soil was estimated under the assumptions that the chemical was fairly uniformly distributed in the top 0.3 inch of the soil and that it is subject to first order degradation. Calculations of the pesticide loading utilized several types of information:

- <u>Half-life of each chemical</u> in the upper horizons of the soil. A single half-life was used for all areas.

- <u>Control program parameters</u> for each region provided by the Economic Evaluation Team, including the total cotton acreage, total acre-treatments, the application rate in pounds per acre, the frequency of application, the date of initial application, and the number of treatments. For CIC and OPM programs, these data were taken from the second round of the Delphi panel survey of cotton production experts, except that the number of applications were calculated on a river basin average basis using information developed by Cooke[32/] on current beltwide control practices. For the Eradication (BWE) program, these data were obtained from Brazzel.[33/]

- <u>A rainfall curve</u> for each region from Agricultural Handbook No. 537[34/] describing the expected distribution through the year of rainfall erosivity.

- For each county, the cotton acreage, production region number and USLE factors. Different cover factors are specified for the various crops growth stages. For the Flint River basin, data were available by drainage area for each reach, so calculations were done on that basis.

- Sediment delivery ratios for each reach of each modeled river segment. The ratios used were calculated for subbasins based on the average size of drainage areas, using a relationship contained in the Soil Conservation Service's (SCS) National Engineering Handbook.[35/] The ratios ranged from 10 to 18 percent, except that lower ratios were used in a few areas to account for local sinks.

- For each county, the relative contribution of runoff pesticide to river reaches. This file was constructed for the three river basins by estimating the area of a county contributing to each reach.

For each production subregion for which the pesticide program is defined, the maximum expected residue in pounds per acre and the residue expected at the end of each of 24 bimonthly periods are calculated under the assumption that not all fields will be treated simultaneously, but the treatments will be evenly distributed over the recurrence interval. For example, if the chemical is to be applied every 10 days, then the assumption is made that the applications in a given county would extend over 10 days before all of the fields were

treated. The pesticide residues (P), averaged over the county, are found by the following equation:

(1) During a period of application,

$$P = \frac{R\,F}{D}\,1-e^{(-Dt)}, \text{ where}$$

R is the application rate, in pounds per acre,

F is the frequency of application, in days,

D is the degradation rate, which is related to the half-life, $t_{1/2}$, as

$$D = \frac{-\ln (0.5)}{t_{1/2}}, \text{ and}$$

t is the time since the first application.

(2) The time of maximum residue will be the end of the application period:

$$t_{max} = \frac{\text{Number of treatments}}{F}$$

which, when substituted into equation (1) will give the maximum expected residue, P_{max}.

(3) After applications cease,

$$P = P_{max}\; e^{-D(t-t_{max})}$$

For each county, the gross erosion expected for each of the 24 bimonthly time periods is calculated based upon the appropriate curve published by the SCS representing the distribution of rainfall erosivity through the year. The expected pesticide runoff is then computed for each period from the soil loss and the residues that were calculated for the applicable region. Pesticide runoff from the county is then apportioned to reaches of a receiving river or rivers for some specified period, and the sediment delivery ratios are applied. This results in pesticide loadings in tons for each reach of every modeled river segment.

In order to perform these calculations, a program called USLRC was written in FORTRAN. A flowchart for the program, a complete listing, and outputs for the three river basins can be found in KTR 194-80 (Attachment G).

Routing of pesticides through the river systems is modeled by the use of PESTRA, a version of the stream routing model QUAL-II. PESTRA considers the processes of dilution, advection, dispersion, degradation within the water column, settling or adsorption of pesticide to bottom sediments, and degradation of the chemical held by bottom sediments. A description of the model and details of its application can be found in KFR 279-80 and KTR 194-80 (Attachments F and G).

The routing model requires a description of the physical configuration of the stream system to be modeled, a set of coefficients describing its hydraulic characteristics, and an accounting of all input flows from headwaters, tributaries, runoff, and wastewater outfalls. The flow rates used to set up PESTRA for the three river basins were generally quite low, to represent conditions during a prolonged dry period. This flow regime was combined with pesticide loading predictions for 2-week periods of maximal expected pesticide runoff, which usually occur following the last of a series of pesticide applications.

The combination of low flows and large loadings can be expected to result in maximal concentrations of pesticide in the stream systems. Thus, these inputs are used to generate worst-case predictions as a baseline for the effects analysis. The actual flow rates and loading will depend on many factors and cannot be predicted with certainty. The most obvious source of variation is the weather. The pattern of rainfall in each basin will be the primary determinant of both pesticide runoff levels and stream flow rates.

Variations in pesticide runoff (loadings) are mirrored exactly in resulting concentrations in the streams. Thus, if the actual loadings are half of those predicted for the baseline case, the predicted pesticide concentrations in the stream are half of those in the baseline case. When flow rates are greater than those of the baseline (worst) case, pesticide concentrations will also be reduced.

Although detailed flow rate statistics are only available for a few sampling stations in the three river basins served, they serve to verify the expected pattern that wide fluctuations occur in small tributary streams. Flow rates in the major rivers remain more nearly uniform. Consequently, the baseline concentrations predicted for major rivers are closer to the normally expected concentrations, and those predicted for small tributaries are more extreme estimates. This is important to note because the highest concentrations predicted in the three modeled river basins are for small tributaries.

Although the absolute levels of the predictions differ for the various chemicals used under the CIC, OPM, and BWE programs, the same general pattern is seen for pesticide concentrations throughout the river systems. The greatest concentrations in each segment are generally seen at the headwaters of tributary streams. Degradation and dilution cause the concentrations to diminish along the tributary, and they are diluted to much lower levels upon entering the main stream. The overall pattern is very much a function of the association of cotton acreage with reaches of the receiving streams, as well as hydraulics. Both of these factors are constant for all programs and chemicals.

Several of the assumptions used and inherent problems with the modeling methodology place limitations on the resulting predictions of pesticide

transport and distribution. These problems include not only the uncertainties associated with weather-related effects but also the following:

- Pesticide residues in the field are assumed to be uniformly distributed in the surface layer of soil, and chemicals deposited on plants are assumed to wash completely into the soil. This implies a constant availability for runoff of whatever residues are present. In fact, field measurements have shown that residues are more available for runoff soon after the chemicals are applied that at later times. This is of great importance in any analysis of small areas but is less important in a large-area analysis.

- A sediment delivery ratio is used to predict the fraction of runoff pesticide which reaches receiving streams. This is likely to be an overestimate since the fraction of sediment from a field reaching a water body may not carry the same fraction of pesticide. The model ignores any changes during transit from field to stream.

- PESTRA is a steady-state model, and it is applied based on expected values for 2-week periods. This approach was designed for the analysis of large river streams. It is less useful for very local situations, such as small streams and ponds.

- Key input data is available only on the level of counties or regions, so that very local effects cannot be predicted accurately.

- The model is uncalibrated, and sufficient monitoring information is not available to properly calibrate it. However, some pesticide monitoring data are available and are consistent with the general predictions of the modeling that dangerous levels of pesticide will not normally occur in the three modeled river systems.

In light of the points mentioned above, it is apparent that the transport and distribution modeling cannot be expected to yield a precise prediction of concentrations which will occur throughout the modeled river basins. Rather, the model predictions are used as the basis for overall comparisons among programs and to point out general areas of potential hazards.

Nontarget Agriculture

The purpose of the Nontarget Agriculture module is to estimate potential contamination of plants and animals and their products, through unintentional pesticide drift onto nontarget areas. Included in this module are analyses of residues in foods (to be used in the Human Ingestion module) and market loss of plant and animal products due to contamination.

The identification and quantification of adverse effects on nontarget food and feed crops, domestic animals, and commercial honey and wax production follow the outlined EEP methodology with some modification. The methodology employed in the estimation of such impacts is basically the following:

- Calculate mean pesticide residue levels immediately following a pesticide application for each considered crop in the river basin. These mean levels are the product of the incremental acreage distribution

and the pesticide classes divided by the total crop acreage in the river basin.

- Calculate the mean residue level which would be present on food and feed crops immediately following the final pesticide application when the pesticide is applied in series.

Degradation is expected to occur between applications. However, if spray intervals are less than the rate of degradation, a pesticide residue buildup would be expected to occur from application to application. The algorithm used to calculate degradation over time and pesticide buildup with sequential pesticide series applications is:

$$Q = Q_o \left(e^{-K \Delta t}\right)^i$$

where, Q = residue at the end of the pesticide application series,

Q_o = residue immediately following an application,

Δt = spray interval in days, and

K = .693 ÷ half-life.

No loss due to degradation is considered from the last application to actual harvesting of crops. The crops immediately adjacent to treated areas are assumed to be equally mixed with nonaffected crops upon harvest for a mean pesticide residue level for the total crop.

- Remove from consideration any crops harvested prior to spraying.

- Compare direct application rates recommended on crops and those used in the boll weevil strategies. Then estimate crop loss due to phytotoxicity with information on pesticide phytotoxicities.

- Present mean residue levels in tabular form for input into the human ingestion module. Compare mean residue tolerance levels with established U.S. tolerances on or in raw agricultural commodities.

- Determine economic loss due to pesticide accumulation in food and feed crops or phytotoxicity.

- Calculate domestic animal exposure from ingestion, inhalation, and dermal routes.

Ingestion by domestic animals is a function of diet and accumulated residue in feed crops. Using the mean residue level, the daily intake is calculated for livestock and poultry of primary importance in the area. It has been assumed that dermal and inhalation routes of exposure will not play significant roles in livestock and poultry exposure. For these two routes to be significant, the animal must be present in an area while it is being sprayed. Livestock would likely be kept out of areas while treatment is made. In the case of poultry, most broiler operations are of the confinement type which shelters the poultry from the direct effect of sprays. Therefore, there is a very low probability that either livestock or poultry will be directly exposed.

- Compare daily dietary intake for livestock and poultry with pesticide feeding and exposure studies to determine possible residue levels resulting in meat, milk, and eggs and possible toxicity.

- Estimate losses from residue accumulation in meat, milk, or eggs. Compare mean residues

with established U.S. tolerances for residues in or on raw agricultural commodities.

- Review literature on protection of apiaries from spay drift and determine current practices in bee and honey production areas where cotton is currently treated.

Aquatics

The review of the potential impact of alternative insect control programs to the aquatic systems of river basins is basically a predictive assessment, using approximations of existing conditions (resulting from CIC) as the baseline. Ideally, there would be an abundance of information assessing the effects of the existing control techniques on the environment for use as a baseline. The potential impacts of the proposed OPM and BWE strategies would then be compared relative to this baseline. Given the variety of insect control techniques now employed and the lack of information about the effects of these techniques, this is not as simple and straightforward an approach as it would seem.

Following the description of each river basin's aquatic systems, the effects of the CIC strategy on both the lotic (running water) and lentic (standing water) habitats are assessed. At the heart of this is the evaluation of the insecticide residues predicted in the T&D module and their relationship to residues actually detected in that river, including residues detected in each river and its tributaries and those found in fish sampled from its waters. In determining the impacts of each program on each river basin, the maximum residue detected in that river basin is used for comparison. This is in keeping with the worst-case approach taken throughout the evaluation. In addition, this provides a common approach throughout this module, allowing

conclusions to be drawn on the relative impacts of each program, as well as the absolute impacts. This is followed by the comparison of these residues to those known to cause toxic responses in organisms under laboratory and field conditions. The interpretation of these results concern the effects on individual species and populations within each river basin. From this, estimates of residues are made for input to the Human Ingestion module.

No reference is made as to the possible effects of each program's insecticide use on phytoplankton and higher plants. During the preliminary analysis, it was determined that the low concentrations of the insecticides used in the boll weevil programs are relatively nonphytotoxic and should have no adverse effect on this component of the aquatic ecosystem.

Wildlife

The Wildlife module estimates the uptake by and effects of pesticides on wildlife occuring in the study area. A major pathway for bioaccumulation occurs sequentially through the food chain. Wildlife, whose primary food supply is associated with vegetation which may contain pesticide residues, are the most susceptible. Insectivorous mammals and birds are often the first vertebrates to consume pesticide residues, while carnivores, higher in the food web, might accumulate even greater residues.

To avoid overlooking any potentially affected species, preliminary work involved identifying all land vertebrates presented in the three river basins. Appendix B, KFR 302-81 (Attachment H) lists the birds, mammals, reptiles, and amphibians in the Flint, Red, and Santee River basins.

Wildlife populations at immediate risk are those residing in or near treated cottonfields where spray may be inhaled or adsorbed on the skin. Wildlife populations need not reside in the immediate area of treatment to be affected

via ingestion because drift and runoff may move pesticides over large distances. In this case, a primary consideration is the degradation rate of the pesticide in use.

It is clearly impractical to attempt to assess the ecological effect of boll weevil pesticides on the hundreds of birds, mammals, reptiles, and amphibians living in potential treatment areas. Therefore, a list of vertebrate species was developed that would most likely experience the pesticides' impact through anticipated routes of exposure. The chosen species represent the most likely cases of pesticide effects on indigenous wildlife.

Criteria used to determine potentially affected species include the following:

- taxonomic representation
- habitat niche
- abundance
- appearance in the human food chain
- geographical distribution
- trophic representation
- similarity to laboratory tested species

Under these criteria, the final list of representative species had to include (1) at least one species of bird, mammal, reptile, and amphibian, (2) species most closely associated with the habitats in the near cottonfields, (3) species of sufficient abundance to allow field investigation of pesticide effects on population dynamics if deemed appropriate, (4) species used by humans for food, (5) species with beltwide distribution so that program effects could be compared from basin to basin, (6) species representative of all likely routes of exposure, i.e., herbivores, insectivores, granivores, carnivores, piscivores, and (7) species closely related to those treated in the laboratory

for pesticide toxicity. All chosen species had to meet criteria 2, 3, and 5 while criteria 1, 4, 6, and 7 had to be met by at least one species.

A preliminary list of cottonfield wildlife species had been compiled from field observations by Roach[36/] in Mississippi. All representative species except the painted bunting, noted for feeding on boll weevils and boll worms[37/] were found in Roach's study on cottonfields.

To assess the effects on wildlife of pesticides sprayed on cotton to control boll weevils, one must consider three routes of exposure: (1) inhalation, (2) dermal, and (3) ingestion. The following describe the analytical methods used to estimate exposure by each route.

Inhalation -- Exposure via inhalation is estimated by assuming a uniform concentration of pesticide spray in the volume of air contained above a representative 30-acre cottonfield up to 25 feet in height for aerial sprays and up to 2 feet for ground applications. Calculated volumes are 32.67×10^6 ft.^{3} (9.2512×10^5 m^3) and 2.6136×10^6 ft.^{3} (7.4009×10^4 m^3) for the respective spray heights. Expected application rate (lb. a.i./acre) of each pesticide is multiplied by 30 acres, divided by the appropriate volume, and converted to mg/liter. Time of inhalation exposure is calculated based on rate of descent of the appropriate droplet size (volume median density) under each pesticide formulation. Total pesticide inhaled by a representative species is calculated by multiplying each species minute volume (breaths/min X tidal vol.) by the number of minutes the spray is airborne. This volume of air in liters times the airborne concentration in mg/liter gives the dose. A worst-case exposure in terms of concentration occurs under the highest rate of application (lb. a.i./acre) of the most toxic boll weevil pesticide sprayed with a nozzle that delivers a very small droplet size.

Ganyard (pers. comm.) stated that droplet size of boll weevil pesticides range from 250 to 400 microns. Particles of this size fall at an average rate of 4.2 (2.5 to 5.9) feet per second in still air. Spray vehicles and local winds that produce air turbulence cause droplet particles to remain airborne longer; therefore, the above time of fall is doubled for this analysis. Fall from aerial application takes 12.5 seconds and from ground applications 1 second. Potentially affected wildlife species are thus subject to the lower airborne concentrations for a longer period of time during aerial application than during the ground spray application. However, the total inhalation dose at either application height, assuming the same application rate (lb. a.i./acre), is equivalent.

Direct Dermal Exposure -- Dermal exposure is estimated by assuming all pesticide spray remains in the cottonfield; i.e., no drift occurs. A generalized 30-acre cottonfield was used to compute surface area on which spray droplets land.

Total surface area for spray deposition consists of (1) leaf surface area and (2) soil surface area. Using an average of 80 percent ground cover (65-95 percent range) in a typical mature cottonfield and a leaf area index of 4 (total leaf surface area of agricultural crops exposed to sunlight),[38/] the surface area of leaves on 30 acres is 4,181,760 $ft.^2$ (388,500 m^2).

A pesticide application rate of 1 lb. a.i./acre, for example, distributed uniformly over the calculated total surface area gives a residue concentration of 32.967 mg/m^2.

Dermal exposure to wildlife is considered to be the calculated pesticide surface residue concentration applied to a representative species' body surface area and is calculated according to the following formula:[39/,40/]

$$SA = 10W^{0.667}$$

$$SA = \text{surface area in cm}^2$$

$$W = \text{species average weight in grams}$$

Dermal Exposure Via Contaminated Vegetation -- Direct evaluation of dermal exposure via contaminated vegetation (CV) depends on estimation of variables such as activity level, time spent in cottonfields, body surface area, and rate of grooming, most of which are unknown. An alternative to direct estimation is to assume CV exposure is some fraction of direct dermal exposure from spray, since the latter dosage is determined by application rate and a species' body surface area. A species' metabolic rate, and hence its activity level, feeding, and grooming rates, is a function of its body weight. Small mammals have a proportionally higher metabolic rate per gram body size than larger mammals. In turn, body surface area has been determined directly from body size.

CV exposure will, therefore, be computed as a logarithmic function of body size in grams according to the formula:

$$ECV = EDD \times Wg^{-.25}$$

where ECV = exposure from contaminated vegetation

EDD = direct dermal exposure from spray

Wg = body weight in grams

Representative species' dermal exposure is the sum of estimated direct dermal and vegetation contact exposures.

Ingestion — Levels of exposure via ingestion depend on food habits of the species in question. Five feeding types are considered: herbivores, insectivores, granivores, carnivores, and piscivores.

Herbivore ingestion exposure is determined for the cottontail rabbit, cotton rat, and white-tailed deer.

Herbivores ingest pesticide as leaf residue (calculated above for dermal exposure) on plants in or near treated fields. Highest levels will naturally occur if all residue remains on plants in the treated 30-acre cottonfield and all plant material consumed is from that field. All three mammalian study species are herbivorous, so intake of contaminated plant matter in the diet is estimated for each. Intake is determined based on expected or estimated dietary composition of cotton plants and for a total cotton plant diet and daily food intake in grams.

A 6-foot (1.8 m) row containing 20 cotton plants (Bull, pers. comm) with a dry leaf biomass of 268-356 grams[41/] gives a 30-acre average total wet leaf weight (assuming 75 percent water content), of 41,941.844 kg. At a 1 pound a.i./acre level of application uniformly distributed over all leaf surfaces under conditions of 80 percent cotton plant ground cover (94 percent of total surface area is leaves), a residue level of 305.36 mg/kg is estimated. Based on the 1 lb. a.i./acre rate giving a residue of 305.36 mg/kg of plant leaf, a cotton rat that ingests 39 grams of cotton plant per day would (under conditions of no pesticide degradation) ingest 11.9 mg. of pesticide. Assuming a body weight of 155 g, the dose level would be 76.8 ppm.

Insectivore exposure is determined by assuming insects ingested have a surface residue level equivalent to that found on plants. Insects are assumed to have

a uniform weight of 0.01 grams[36/] and a body surface area of 1 cm^2. Thus a total insect diet of 8 grams per day is equivalent to ingesting residue on 800 cm^2 of surface area.

Granivores or seed eaters, such as the mourning dove, ingest pesticide residues adhering to seed surfaces. Seeds, for the most part weed seeds, are assumed to weigh 0.002 grams each and to have a surface area of 0.05 cm^2. Seed eaters consuming, for example, 10 grams of seeds ingest 5,000 seeds and, therefore, residue on 250 cm^2 of surface area. Species, such as the red wing blackbird, that ingest both seeds and insects are assumed to apportion their daily intake equally (by weight) between the two food types.

The terrestrial carnivore considered in this analysis, the hognose snake, is assumed to ingest a single Fowler's toad. Its pesticide intake via ingestion is, therefore, the level of pesticide accumulated dermally, by inhalation, and by ingestion of the toad.

The belted kingfisher, a fish eater, is assumed to ingest 20 grams of fish per day at the highest level of fish tissue residue found in the Aquatics module.

A potentially affected species' total dose of boll weevil pesticide is computed as the sum of the inhalation, dermal, and ingestion exposures during the first 24 hours.

Fish Farms and Hatcheries

This module is included in the EEP assessment to quantify the exposure of fish in commercial ponds or hatcheries receiving pesticides directly or indirectly via drift or runoff. Fish farms and hatcheries found in each of the States containing a river basin being evaluated were identified using several U.S. Fish and Wildlife Service publications and lists from the various State

agencies charged with maintaining such data. The towns in which facilities were found were checked to eliminate those facilities not located within the 15 river basins being evaluated. The remaining facilities were then contacted by telephone to determine the species raised, size of the facility, and water source. Data on these facilities can be found in KFR 279-80 (Attachment F).

In this report, the assessment of each program's effect on fish farms and hatcheries was included in the results discussion of the Aquatics module. Information received through the direct contact of fish farm operators was used to supplement this portion of the evaluation.

Endangered and Threatened Species

The Endangered and Threatened (E&T) Species module is a special case of the Wildlife module. Section 7 of the Endangered Species Act of 1973 states that Federal Agencies shall not authorize, fund, or carry out actions jeopardizing the continued existence of an endangered or threatened species, nor take action which will result in the destruction or adverse modification of its critical habitat.

The application of the E&T species module of the EEP model involves the identification of those E&T species found throughout the Cotton Belt addressed by the evaluation, their population distribution, and critical habitat characteristics.

The data was obtained by contacting the appropriate State and Federal Agencies. These included State Fish and Game Commissions of each State concerned, Natural Heritage Programs, and various State conservation agencies. In addition, the U.S. Department of the Interior's Office of Endangered Species

was a valuable source of information. A listing of the E&T species located in the river basins evaluated can be found in KFR 279-80 (Attachment F).

Analysis of the effects of boll weevil control programs on E&T species required a two-step process. First, each species was examined according to several criteria used to select representative species to determine likely exposure to insecticides used in the programs. Second, those E&T species that would likely receive some effects (i.e. residues) were compared with the most closely related representative species to determine likely hazard.

Human Ingestion

The Human Ingestion module quantifies pesticides in the food supply and potential uptake by humans. More specifically, the module identifies important food types, estimates the pesticide residues in the foods over time, determines human intake of these foods, and estimates the amount of pesticides ingested by humans.

The basic procedure for estimating human exposure through the diet is as follows:

(1) establish which food items are most likely to contribute to potential pesticide accumulation in humans, locally;

(2) estimate the residue levels in those food items for different points in time after harvest;

(3) estimate the amount of each food item that a "representative" human ingests on a daily basis;

(4) estimate the rate at which the body eliminates the pesticide after ingestion; and

(5) combine the above to estimate average daily intake and total accumulation over time.

The full mathematical formulation of this process can be found in Appendix D, KFR 302-81 (Attachment H).

The full procedure was basically designed to look at pesticides or other chemicals which are relatively persistent and tend to accumulate in the adipose tissue over time. For nonpersistent pesticides, which rapidly degrade in nature as well as in the human body, several simplifying procedures can be made which greatly facilitate calculation of "upperbound" daily intakes.

For each food item in the diet, the following is calculated:

Q	x	R	x	E
Quantity eaten in 1 day (kg)		Residue (mg/kg)		Elimination Factor

This calculation gives the amount of pesticide in mg ingested via that food item. These values, once calculated for each food item, are then summed over all food items in the diet, and the result divided by a "resident" person's body weight (W) in kg. The result is the effective daily intake (D_I) in mg/kg of body weight for that day.

The final estimated upper bound residue (R_T) in the body on a given day is then calculated by multiplying D_I by the number of days (T) it takes the body to effectively eliminate a single dose of the pesticide. (This is equivalent to assuming that all the pesticide that is not eliminated after the first day of ingestion remains in the body for T-1 days.) Thus, we get:

$$R_T = D_I \times T = \sum_{\text{diet items}} \frac{Q \times R \times E \times T}{W}$$

An initial work table of diet items was developed as follows:

WORK TABLE FOR HUMAN INGESTION CALCULATION

Food	Q (kg)	R (ppm)	E	T (days)	W (kg)	Contribution to R_T (mg/kg)
Meat	0.20		0.25	10	50	
Grain[a]	0.28		0.25	10	50	
Milk Products	0.23		0.25	10	50	
Eggs	0.03		0.25	10	50	
Fruits	0.11		0.25	10	50	
Sugar	0.03		0.25	10	50	
				R_T = Sum =		________

[a] Includes soybeans (although soybeans are not a grain, they are included in with grains because one of the major uses of soybean is soybean meal which is used in the making of breads, breakfast foods, and meat additives).

The diet values shown in the table are taken from a USDA 1977 survey of the eating habits of persons in the South, which is given in Appendix E, KFR 302-81 (Attachment H). They represent total daily intake of each food item. The elimination factor E is an estimate of the amount of pesticide remaining in the body after 1 day. The value of 0.25 chosen is considered an overestimate, particularly since we have assumed the 25 percent of the pesticide remaining after the first day does not appear (no degradation) until the 10th day. Of course, using 10 days as the time T to total elimination is also considered an overestimate, (4 or 5 days is probably a more realistic estimate), but 10 days certainly is in keeping with the worst-case approach. Finally, the average weight of 50 kg is low but again using a lower weight will give a larger value.

Using the above values, the table can be further simplified to the following:

SIMPLIFIED TABLE FOR HUMAN INGESTION CALCULATION[a]

Food Item	$P = \frac{Q \times E \times T}{W}$	R (ppm)	P x R
Meat	0.010		
Grain	0.014		
Milk Products	0.011		
Eggs	0.0015		
Fruits	0.0055		
Sugar	0.0015		
		Sum = R_T =	________

[a] Q = quantity of food item in kg
E = 0.25 = elimination factor
T = 10 = days to total elimination
W = 50 = weight in kg of representative human
R = residue in ppm (mg/kg)
R_T = total daily intake in mg/kg

This table is presented for each pesticide and each river basin for each of the three programs. For each table, the residue value for each food item category will be that of the food item which has the highest residue level in that category, except for the meat category. Thus, for grains, wheat, corn, soybeans, and rice are considered. Whichever of those has the highest residue level, it is assumed that a representative person eats that grain product for 10 days in a row. Similar assumptions are made for milk products and fruits. For sugar, sugarcane residues are used and for eggs, chicken egg residues are used. For meat products, a dietary intake proportional to the amounts given in the USDA diet study are used, which are:

Beef, Pork	63 percent
Poultry	26 percent
Fish	8 percent
Wildlife	3 percent (an overestimate)

Because the meat residue value requires calculations, the human ingestion table is preceded by a table of the following form:

MEAT RESIDUE CALCULATION

Source	Proportion = p	Residue = r	p x r
Beef, Pork	0.63		
Poultry	0.26		
Fish	0.08		
Wildlife	0.03		
		Sum = R for meat =	________

The residue values entered, except for those associated with fish, are the product of a basic residue factor and an elimination factor of 0.25. The reason for including the elimination factor is similar to the reason given for including an elimination factor in the initial work table. The residue values calculated and presented in the nontarget agriculture and wildlife sections are maximum daily intakes for each of the species considered. These values assume that the species eat sprayed plants immediately after treatment and, in the case of wildlife, that the wildlife come into direct contact with the spray (dermal or inhalation exposure). Because of the rapid degradation of these chemicals and the rapidity with which they are metabolized or eliminated by these species, a very conservative figure of 0.25 was used to take into account some degradation/elimination.

Research Program Conflicts

Broad scale insect control programs expose large areas to pesticides. Other programs conducted in the vicinity of the pesticide control operations may be impacted. Research on soil, plants, animals, or other aspects of the environment may be altered in some way. This module is intended to investigate these effects and estimate those losses which might occur.

Based upon an analysis of the situations at hand, together with previous experience with similar analysis relative to the boll weevil trials, three general groups were identified as those likely to be conducting research which could potentially be impacted. They are:

- agricultural chemical producers engaged in screening potential products for cotton insect control;
- university groups conducting research on subjects such as breeding of insect resistent cotton varieties or developing methods of nonchemical control; and
- State and Federal research facilities likewise engaged in the above research activities.

In all three cases it was hypothesized that both the CIC and OPM control alternatives would not likely result in adverse impacts to ongoing research. Since CIC is simply a continuation of current practices, it is used essentially as a baseline against which to measure change. In the case of the OPM program, the components are esentially the same as CIC in terms of pesticides used and the manner of application. The principal difference is in terms of formalizing many current practices, together with increased cotton scouting activity. These differences would not result in an increased likelihood of research program conflicts or in changes in the nature of research impacted.

Due to the nature of the BWE alternative (mandatory participation of all cotton growers), there is a possibility of potential program impact upon cotton-related research because of quarantine procedures. With respect to the agricultural chemical producer, the types of potential impacts take on two

forms. The first and primary impact is the potential mandatory treatment of experimental cotton acreage with pesticides other than those being screened for efficacy in terms of cotton insect control. There is a potential for sizeable losses to the manufacturer if field testing becomes impossible. There is also the additional, and essentially nonquantifiable, cost to cotton producers of potentially beneficial control agents not reaching the market place. The second potential impact is actually a component of the first in that BWE quarantine implementation could restrict the import or rearing of fertile boll weevils in all areas. Such restrictions could inhibit research in boll weevil pesticide screening.

For each of the next two research groups, potential impacts essentially would be the same, i.e., the disturbance of cotton acreage devoted to experimentation. While there are a great number of types of experiments which could be impacted, the principal ones are the breeding of insect resistent cotton varieties and the development of nonchemical means of control. As in the case of agricultural chemical producers, the mandatory treatment of such acreage in a quarantine program by the prescribed means (chemical and nonchemical) could have the effect of negating observable effects of experimental control measures. There is also the nonquantifiable effect or cost to cotton producers of potential research and methods development not rising to the operational level.

An informal telephone survey was, therefore, taken of research groups in the Santee, Flint, and Red River basins to determine whether or not the above impacts could be expected to occur in the areas under study.

Social Perception

The objective of the Social Perception module of the EEP methodology is to evaluate the possible effects of a pesticide program on the quality of life

of the inhabitants of the program area. This is generally done by quantifying observed or expected social effects in a relatively subjective manner. The usual strategy is to first identify such effects by surveying area inhabitants and then classifying the effects into a number of categories such as human health, wildlife, physical surroundings, and others. The effects are further classified as beneficial or adverse and then using a weighting system, summed into an index of impact. It is not intended to constitute a bona fide social impact assessment, which is beyond the scope of this study. It is simply a means of evaluating societal perceptions of such programs. The entire procedure is detailed in Appendix E of KFR 168-78.[28/] Generally, the perceived environmental effects associated with a program are based almost entirely upon observed impacts. In the case of a predictive analysis, the absence of observed impact results in persons being unable to formulate a "perception."

The fact that the beltwide assessment is predictive in nature necessitated a much more qualitative approach to evaluating social perception.

LOCAL IMPACT IN TRIAL AREAS

Introduction

These results present the environmental effects of several boll weevil control options -- the Optimum Pest Management Trial in Mississippi (OPM), the Boll Weevil Eradication Trial in North Carolina (BWE), and the Current Insect Controls used in each State (CIC-MS and CIC-NC), during the 1978-1980 trial years. The trials have been conducted to provide data needed to assess the technical feasibility and potential impacts of implementing one of several programs across the Cotton Belt. Three previous annual reports assessed the

potential environmental hazards of the trial strategies (Attachments B, C, and D). Similarly, a report was prepared summarizing the results of all three crop years (Attachment I). The yearly evaluations and summary report were prepared to assist the Environmental Evaluation Team (ENET) meet its responsibilities in evaluating the boll weevil trials.

These results provide a review of the potential hazards of each trial option during the past 3 years, as indicated by the numerical indices calculated with the BOLL-1 model. A revised set of these indices is presented for each year of the trials, taking into consideration slight methodology revisions and sources of data identified after some results were originally reported. The indices are then combined to calculate overall indices or Q values, using the weights and thresholds obtained during the third and final round of the ENET's Delphi survey of weights and thresholds.

Several factors influence the indices addressed. These include the influence of the weights and thresholds selected for each trial area on the magnitude of the indices calculated and the effects of weather and insects other than the boll weevil on the quantities and types of insecticides used in the trials.

Also included is a summary of the residue data collected by APHIS during the trials and its correlation with the changing patterns of insecticide use identified during the trial years. In addition, simulated overall indices are included for each of the trial areas for relative comparisons between strategies.

A summary of the areas involved in each year of the trial strategies is given in Table 2.

OPM was conducted in Panola County, Mississippi. This program was a modification of the Mississippi Cooperative Extension Service's (MCES)

TABLE 2

COTTON ACREAGES IN THE FOUR TRIAL AREAS DURING THE THREE PROGRAM YEARS

	1978		1979		1980	
	Acres in BET Sample Fields[a]	Acres in County	Acres in BET Sample Fields[b]	Acres in County	Acres in BET Sample Fields[c]	Acres in County
BWE	2,335	11,965	1,694	13,560	1,050	26,729
CIC-NC	68	20,100	734	20,100	826	22,878
OPM	1,824	32,500	1,298	32,000	3,050	40,000
CIC-MS	587	2,800	302	3,200	650	8,000

[a] 122, 16, 64, and 32 fields, respectively.

[b] 114, 21, 64, and 32 fields, respectively.

[c] 68, 20, 64, and 32 fields, respectively.

voluntary cotton insect management program. A major goal of this program was to demonstrate the feasibility of the implementation of a community-wide optimum cotton insect pest management program, based on voluntary producer participation.

During the trials, 15 different insecticides were used to control pests on cottonfields in Panola County. A major reason for the variety of chemicals used in the County was the fact that individual producers conducted their own in-season control operations. Diapause treatments, conducted yearly by MCES, used 3-4 applications of methyl parathion. Insecticide application data for the OPM sample cottonfields is summarized in Table 3.

The Biological Evaluation Team's (BET) sample fields in Panola County were used as the basis for the environmental evaluation of the OPM trial. As previously stated, these fields were chosen to provide a representative sample of treatment practices and field conditions experienced on cottonfields throughout the county. They provided a detailed, readily obtainable view of pesticide application and land use patterns for adjacent areas. Processing data from all participating acreage would not be cost-effective due to the potential availability of data on all fields, costly increases in data acquisition, handling and analysis time and the small incremental benefit to the evaluation.

The current insect control practices used throughout the remainder of Mississippi provided the baseline against which the OPM trials were compared. Factors that the evaluation teams compared included insecticide use, beneficial insect population levels, and cotton yield. Current practices ranged from no insecticide application to the insect management programs currently being implemented by the MCES, grower organizations, and commercial consultants.

TABLE 3

COTTON INSECTICIDE DATA FOR OPM SAMPLE FIELDS IN PANOLA COUNTY, MISSISSIPPI[a]

Chemical and Application Rate (lb./Acre)	Average Number of Pounds Applied Per Acre in the OPM Area 1978	1979	1980
Acephate 1.30-2.00	--	0.04	--
Azinphos-methyl 0.16-0.25	--	--	0.01
Chlordimeform 0.13-0.25	--	0.05	0.03
Chlorpyrifos 0.33-0.50	--	0.01	--
Dicrotophos 0.10-0.25	0.09	0.35	0.07
Dimethoate 0.10-0.20	0.02	0.35	0.01
Endrin 0.27	--	0.01	<0.01
EPN 0.50-0.75	0.28	0.38	0.22
Fenvalerate 0.05-0.20	0.03	0.12	0.11
Methomyl 0.30-0.45	0.22	0.33	<0.01
Methyl Parathion 0.25-1.50	0.28	0.82	2.29
Monocrotophos 0.20-1.00	<0.01	0.01	0.02
Permethrin 0.10-0.20	0.13	0.03	0.03

[a] Obtained from Biological Evaluation Team data.

Pontotoc County, Mississippi, was selected as a representative Current Insect Control (CIC) area because of the variety of practices in use there.

The BET gathered field data each year from 32 sample fields in Pontotoc County. This represented almost all of the cotton producers in that county. As in Panola County, the data collected from these fields were treated as a representative sample and provided the basis for the environmental evaluation of CIC practices throughout Pontotoc County. The application data for the 32 sample cottonfields are summarized in Table 4.

The BWE trial involved 16 North Carolina and 2 Virginia cotton-producing counties. The APHIS operational program was a cooperative venture with funding being supplied jointly by participating cotton producers (50 percent), APHIS (25 percent), and the North Carolina Department of Agriculture with cooperation from North Carolina State University and the Virginia Department of Agriculture and Commerce (25 percent).

The BWE program differed from the Mississippi program in that 100 percent grower participation was necessary. Legislative mandate for this exists in the North Carolina Uniform Boll Weevil Eradication Act (Article IV, F of the General Statutes of North Carolina, as amended in 1977). In Virginia, the legislation mandate exists in Article 6 of the Virginia Pest Law.

The data collected on the biological evaluation sample fields were used as the basis for the environmental evaluation for the entire BWE trial area and served as the basis for the pesticide data presented in Table 5.

CIC areas were also located in North Carolina in which current insect control practices were monitored. The first area was composed of Scotland and Robeson Counties. The second was Cleveland and Gaston Counties. The former area has

TABLE 4

COTTON INSECTICIDE DATA FOR CIC-MS SAMPLE FIELDS IN PONTOTOC COUNTY, MISSISSIPPI[a]

Chemical and Application Rate (lb./Acre)	Average Number of Pounds Applied Per Acre in the OPM Area 1978	1979	1980
Acephate 1.30-2.00	<0.01	--	<0.01
Azinphos-methyl 0.16-0.25	0.08	--	0.06
Chlordimeform 0.13-0.25	0.03	--	0.01
Chlorpyrifos 0.33-0.50	0.01	0.14	--
Dicrotophos 0.10-0.25	0.11	0.01	--
EPN 0.50-0.75	0.06	--	0.11
Methomyl 0.30-0.45	--	0.07	0.12
Methyl Parathion 0.25-1.50	0.02	0.71	0.69
Monocrotophos 0.20-1.0	0.10	0.01	--
Permethrin 0.10-0.20	0.02	0.01	0.06
Toxaphene 1.50-2.00	0.01	0.72	0.13

[a] Obtained from Biological Evaluation Team data.

TABLE 5

COTTON INSECTICIDE DATA FOR BWE EVALUATION ZONE SAMPLE FIELDS IN NORTH CAROLINA[a]

Chemical and Application Rate (lb./Acre)	Average Number of Pounds Applied Per Acre in the BWE Area		
	1978	1979	1980
Diflubenzuron 0.06	0	0.02	0
Organophosphates 0.25-1.13	8.8	0.1	0
Methomyl 0.38-1.50	0.12	0.03	0
Pyrethroids 0.09-0.10	0.13	0.20	0.12
Chlordimeform 0.13-0.25	0.02	0.03	0.01
Toxaphene 1.00-2.00	2.90	0.10	0

[a] Obtained from Biological Evaluation Team data.

similar conditions to those found in eastern South Carolina and Georgia and large portions of Alabama and Mississippi. These areas were established to provide data that would allow a comparison of the BWE strategy and current insect control practices. The current insect control practices in the Scotland and Robeson County check area were not addressed in the 1978 evaluation because sufficient data were not available at that time. Such data were available for 1979 and 1980, so the current insect control practices used during these years were included in the yearly evaluations. These are referred to as the CIC-NC practices.

Data for the CIC-NC fields in the Scotland - Robeson County check area are presented in Table 6.

Summary Evaluation of Three Trial Years

As described earlier, the BOLL-1 model calculates numerical indices for seven areas of potential hazard -- offsite drift, human ingestion, research conflicts, endangered and threatened species, fish farms and hatcheries, wildlife, and acquatics -- and combines these into an overall index, Q, which is defined as the weighted sum of the normalized indices. These indices provide a measure of the relative environmental hazards of the activities of each trial strategy. They should be viewed cautiously as an absolute measure. They are not comprehensive measures of impact and are intended primarily to represent the potential hazards associated with the control strategies. The indices calculated for the 3 years of trials are presented in Tables 7-18.

Several factors are responsible for the differences between the indices presented in Tables 7-18 and those reported in earlier yearly evaluations (Attachments B and C). The first factor concerns slight changes made to the methodology with which the offsite drift and human ingestion indices were

TABLE 6

COTTON INSECTICIDE DATA FOR CIC-NC SAMPLE FIELDS IN SCOTLAND AND ROBESON COUNTIES, NORTH CAROLINA[a]

Chemical and Application Rate (lb./Acre)	Average Number of Pounds Applied Per Acre in the CIC-NC Area		
	1978	1979	1980
Diflubenzuron 0.06	0	0	0
Organophosphates 0.25-1.13	3.6	2.8	1.9
Methomyl 0.38-1.50	0.51	0	0.10
Pyrethroids 0.09-0.10	0.48	0.50	0.55
Chlordimeform 0.13-0.25	0.13	0.32	0.08
Toxaphene 1.00-2.00	4.30	2.00	0.48

[a] Obtained from Biological Evaluation Team data.

TABLE 7

1978 INDICES OF IMPACT FOR THE
OPM AREA, MISSISSIPPI

Module	Index	Threshold	Normalized Index	Weight	Contribution to Q
Offsite Drift	8778	36,581	0.240	213	51
Human Ingestion	2.44	3.38	0.722	286	206
Research Conflicts	0/0	3.3/4.1	0	133	0
E&T Species	0/0	2.5/6.6	0	154	0
Fish Farms	0/0	0.75/0	0	214	0
Wildlife	----	----------	----------	----	----
Aquatics	----	----------	----------	----	----
					Q = 257

TABLE 8

1979 INDICES OF IMPACT FOR THE
OPM AREA, MISSISSIPPI

Module	Index	Threshold	Normalized Index	Weight	Contribution to Q
Offsite Drift	10,252	36,625	0.280	213	60
Human Ingestion	5.90	3.38	1.0	286	286
Research Conflicts	0/0	3.3/4.1	0	133	0
E&T Species	0/0	2.5/6.6	0	154	0
Fish Farms	0/0	0.75/0	0	214	0
Wildlife	----	---------	----------	----	----
Aquatics	----	---------	----------	----	----
					Q = 346

TABLE 9

1980 INDICES OF IMPACT FOR THE
OPM AREA, MISSISSIPPI

Module	Index	Threshold	Normalized Index	Weight	Contribution to Q
Offsite Drift	7215	35,913	0.201	213	43
Human Ingestion	5.73	3.38	1.0	286	286
Research Conflicts	0/0	3.3/4.1	0	133	0
E&T Species	0/0	2.5/6.6	0	154	0
Fish Farms	0/0	0.75/0	0	214	0
Wildlife	----	----------	----------	----	----
Aquatics	----	----------	----------	----	----
					Q = 329

TABLE 10

1978 INDICES OF IMPACT FOR THE
CIC-MS AREA, MISSISSIPPI

Module	Index	Threshold	Normalized Index	Weight	Contribution to Q
Offsite Drift	1056	25,745	0.041	213	9
Human Ingestion	0.336	3.38	0.099	286	28
Research Conflicts	0/0	2.7/3.9	0	133	0
E&T Species	0/0	2.5/6.6	0	154	0
Fish Farms	0/0	0.5/0	0	214	0
Wildlife	----	---------	----------	----	----
Aquatics	----	---------	----------	----	----
					Q = 37

TABLE 11

1979 INDICES OF IMPACT FOR THE
CIC-MS AREA, MISSISSIPPI

Module	Index	Threshold	Normalized Index	Weight	Contribution to Q
Offsite Drift	1734	25,745	0.067	213	14
Human Ingestion	1.46	3.38	0.432	286	124
Research Conflicts	0/0	2.7/3.9	0	133	0
E&T Species	0/0	2.5/6.6	0	154	0
Fish Farms	0/0	0.50/0	0	214	0
Wildlife	----	---------	----------	----	----
Aquatics	----	---------	----------	----	----
					Q = 138

TABLE 12

1980 INDICES OF IMPACT FOR THE
CIC-MS AREA, MISSISSIPPI

Module	Index	Threshold	Normalized Index	Weight	Contribution to Q
Offsite Drift	2758	25,324	0.109	213	23
Human Ingestion	1.67	3.38	0.494	286	141
Research Conflicts	0/0	2.7/3.9	0	133	0
E&T Species	0/0	2.5/6.6	0	154	0
Fish Farms	0/0	0.5/0	0	214	0
Wildlife	----	----------	----------	----	----
Aquatics	----	----------	----------	----	----
					Q = 164

TABLE 13

1978 INDICES OF IMPACT FOR THE
BWE AREA, NORTH CAROLINA

Module	Index	Threshold	Normalized Index	Weight	Contribution to Q
Offsite Drift	4400	200,841	0.022	215	5
Human Ingestion	5.10	10.0	0.510	288	147
Research Conflicts	0/0.125	9.1/9.0	0.014	80	1
E&T Species	0/0.375	1.0/14.3	0.026	268	7
Fish Farms	0/0	1.6/30.5	0	149	0
Wildlife	----	---------	----------	----	----
Aquatics	----	---------	----------	----	----
					Q = 160

TABLE 14

1979 INDICES OF IMPACT FOR THE
BWE AREA, NORTH CAROLINA

Module	Index	Threshold	Normalized Index	Weight	Contribution to Q
Offsite Drift	5954	201,375	0.030	215	6
Human Ingestion	0.376	10.0	0.038	288	6
Research Conflicts	0/0	9.1/9.0	0	80	0
E&T Species	0/0.375	1.0/14.3	0.026	268	7
Fish Farms	0/0	1.6/30.5	0	149	0
Wildlife	----	---------	----------	----	----
Aquatics	----	---------	----------	----	----
					Q = 24

TABLE 15

1980 INDICES OF IMPACT FOR THE
BWE AREA, NORTH CAROLINA

Module	Index	Threshold	Normalized Index	Weight	Contribution to Q
Offsite Drift	7812	199,131	0.039	215	8
Human Ingestion	0.150	10.0	0.015	288	4
Research Conflicts	0/0	9.1/9.0	0	80	0
E&T Species	0/0	1.0/14.3	0	268	0
Fish Farms	0/0	1.6/30.5	0	149	0
Wildlife	----	---------	----------	----	----
Aquatics	----	---------	----------	----	----
					Q = 12

TABLE 16

1978 INDICES OF IMPACT FOR THE
CIC-NC AREA, NORTH CAROLINA

Module	Index	Threshold	Normalized Index	Weight	Contribution to Q
Offsite Drift	2666	146,413	0.018	215	4
Human Ingestion	8.230	11.0	0.748	288	215
Research Conflicts	0/0	4.0/3.8	0	268	0
E&T Species	0/0	0.8/14.0	0	268	0
Fish Farms	0/0	1.4/22.5	0	149	0
Wildlife	----	---------	----------	----	----
Aquatics	----	---------	----------	----	----
					Q = 219

TABLE 17

1979 INDICES OF IMPACT FOR THE
CIC-NC AREA, NORTH CAROLINA

Module	Index	Threshold	Normalized Index	Weight	Contribution to Q
Offsite Drift	3808	146,422	0.026	215	6
Human Ingestion	11.2	11.0	1.0	288	288
Research Conflicts	0/0	4.0/3.8	0	80	0
E&T Species	0/0	0.8/14.0	0	268	0
Fish Farms	0/0	1.4/22.5	0	149	0
Wildlife	----	---------	----------	----	----
Aquatics	----	---------	----------	----	----
					Q = 294

TABLE 18

1980 INDICES OF IMPACT FOR THE CIC-NC AREA, NORTH CAROLINA

Module	Index	Threshold	Normalized Index	Weight	Contribution to Q
Offsite Drift	3324	145,899	0.023	215	5
Human Ingestion	6.35	11.0	0.577	288	166
Research Conflicts	0/0	4.0/3.8	0	80	0
E&T Species	0/0	0.8/14.0	0	268	0
Fish Farms	0/0	1.4/22.5	0	149	0
Wildlife	----	---------	----------	----	----
Aquatics	----	---------	----------	----	----
					Q = 171

calculated. These changes were made following the 1978 evaluation to overcome several inconsistencies in the methodology that were discovered during that evaluation. The second factor is the different set of weights and thresholds used to calculate the overall indices. These weights and thresholds were obtained with a three-round Delphi survey. The most refined estimates (third round of the Delphi survey) were used to calculate the overall indices presented in Tables 7-18, while the 1978 and 1979 evaluations (Attachments B and C) reported overall indices which had been calculated using the weights and thresholds determined after the second Delphi round. The third factor contributing to the difference between these overall indices and those reported earlier concerns the wildlife index. Using the methodology described earlier, wildlife indices were initially calculated for the trial areas in 1978 and 1979. However, it was subsequently decided by the ENET that this index was not accurate enough to provide an appropriate assessment for these trials. As a result, the wildlife index was not included in the 1980 trial year evaluation or the 3-year summary evaluation depicted in Tables 7-18.

The offsite drift and human ingestion indices are primarily a function of the acreage of cotton in each trial area and the quantity of insecticides used to control cotton insect pests. Potential problem areas were carefully studied, including the drift of pesticides, the contamination of food crops, exposure of wildlife and rare organisms, and the transport of pesticides to natural and manmade aquatic systems. There have been no indications that any of these potential problems resulted during the 3 years of the trial options. The potential for human ingestion of these insecticides appears to be relatively low, given the make-up of cropland surrounding the cottonfields in the trial areas and the short-lived nature of these chemicals in the environment.

The Research Conflicts module is an important component of the BOLL-1 model because some pest management programs involve large areas and utilize pesticides or other control practices which could disrupt research projects in which much time, effort, and money have already been invested. The boll weevil trials differed in that they only involved the treatment of cotton and, except for the BWE effort, participation was not mandatory.

There have been several potential research conflicts identified with mandatory features such as the BWE trial. The first, discussed in the 1978 evaluation (Attachment B), involved the existence of an agricultural chemical research facility within the BWE buffer zone. This facility, ICI Americas, Inc., located in Goldsboro, North Carolina, was actively involved in the screening of pesticides for use against the boll weevil. An objective of the trial was the elimination of boll weevils within this area and, as such, the rearing or importing of boll weevils was prohibited. This imposed a hardship on this organization and was noted as an impact in the 1978 evaluation.

The mandatory treatment of all BWE cotton acreage, as needed to eliminate the boll weevil, created the potential for the disruption of various research activities involving cotton insect species which may be susceptible to the insecticides used for eradication. However, this situation was not realized. The reduced applications of diflubenzuron and azinphos-methyl resulted in only minor inconveniences.

There were no reports of any research disruptions during the OPM and CIC (NC and MS) trials.

For the most part, there were few problems identified in the Fish Farms and Hatcheries and E&T Species modules. In the BWE trial area, several rare organisms were identified in close proximity to the sample cottonfields but these were plants which were insensitive to the insecticides used.

The Wildlife module's evaluation of the potential hazard of each control strategy addressed the toxicity of each insecticide used to birds and mammals, the quantity of each of these insecticides used, and the comparison of this toxicity data to the avian and mammalian residue sampling data collected by APHIS during each of the trial years. A review of the toxicity data shows that many of the insecticides used to control the boll weevil are toxic to birds and mammals. Use of these insecticides declined during the three trial years, especially in the BWE trial area. The reduction in use of these pesticides further minimized the potential exposure of organisms. However, even low use of these pesticides poses some hazard to wildlife present in cottonfields, especially the more sensitive birds. A review of the insecticide residue data gathered by APHIS showed that few of the insecticides used in the trial areas appeared in bird or mammal tissue, and in no cases did residues approach those known to cause mortality to laboratory tested species. While the exposure of wildlife to pesticides presents some hazard, the residue data does not support any contention that birds or mammals were adversely affected by the trial strategies.

The Aquatics module of the three yearly evaluations consisted of a discussion of several factors that influenced the degree of risk of the trial strategies to each area's aquatic systems. The first of these was the toxicity to aquatic organisms of the insecticides used in each trial. The second factor was the potential for the exposure of aquatic systems near application sites of these insecticides. The first factor was addressed with a toxicity review which indicated that all the insecticides used have been shown to be highly toxic to fish or crustacea under laboratory conditions. The investigation of the chances of insecticide inadvertently entering a waterway showed that there were

very few instances where ponds or streams were adjacent to cottonfields and could receive pesticide via drift during aerial application. The possibility of pesticide entering a waterway in runoff does exist, but the insecticides used most frequently in the trials are all relatively short-lived in soil, minimizing this possibility. A review of the APHIS sampling data did not indicate that there were any adverse impacts to aquatic systems associated with the three years of the trial strategies.

Simulated Overall Indices for Trial Areas

The purpose of this section was to provide simulated assessments of the potential hazards of implementing each cotton insect control strategy in trial areas where it was not actually being tested. This effort was intended to provide additional information regarding the BOLL-1 model's measurement of the relative hazard of each strategy. Because much of the data necessary to make such an assessment with the BOLL-1 model were dependent on the characteristics of the land, and not of the strategies themselves, and because the assumption was made that cotton acreage would not change in response to a change in strategy, many of the indices were insensitive to such an evaluation.

The overall indices calculated for the 1978, 1979, and 1980 seasons are presented in Table 19. As stated earlier, the overall indices for 1978 and 1979 shown in this table are different from those reported in Attachments B and C because, for this simulation, the weights and thresholds calculated during the third round of the Delphi Panel Survey were used for all three trial years. Also, the wildlife indices were deleted to provide a truer comparison. Complete results of this simulation effort can be found in Appendix C, KTR 312-81 (Attachment I).

TABLE 19

SUMMARY OF THE ACTUAL AND SIMULATED OVERALL INDICES Q, FOR THE FOUR TRIAL AREAS, 1978-1980

	1978 TRIAL AREA			
STRATEGY	OPM	CIC-MS	BWE	CIC-NC
OPM	257[a]	181	65	83
CIC	85	37[a]	156	219[a]
BWE	337	295	160[a]	224

	1979 TRIAL AREA			
STRATEGY	OPM	CIC-MS	BWE	CIC-NC
OPM	346[a]	300	141	77
CIC	236	138[a]	203	294[a]
BWE	101	43	24[a]	23

	1980 TRIAL AREA			
STRATEGY	OPM	CIC-MS	BWE	CIC-NC
OPM	329[a]	309	101	170
CIC	247	164[a]	94	171[a]
BWE	65	38	12[a]	13

[a] Indicates actual index calculated during yearly evaluation. All other values are based on simulated data.

The principal data used to calculate these indices concerned insecticide use. These data were based on the "per acre" use of insecticides in the area in which the trial program actually took place. For instance, 2.81 pounds of insecticide per acre of cotton were used to control cotton insects in the OPM trial area in 1980. The assumption was made that the implementation of an OPM strategy in any of the other trial areas would also require 2.81 lb./acre of insecticide to control cotton pests. While this was a very crude estimate, it was necessary for such an assessment to be made.

Comparing the results of the simulation effort, it can be seen that the OPM program generally had the highest overall index when applied over the four trial areas. This was primarily due to a higher human ingestion index resulting from greater insecticide use. On the other hand, the reduced amount of insecticides used, particularly after the first year, resulted in the BWE program having the lowest overall impact in the four trial areas. It should be noted, however, that the overall indices were all low when compared to the maximum value of 1,000.

Pesticide Monitoring Results

This section presents a summary of the 3-year pesticide residue monitoring data compiled by APHIS and referred to in the E&T Species, Wildlife and Aquatics modules of the 3 yearly evaluations, and compares that data with the quantities and types of insecticides used during the trials. The use of insecticides decreased somewhat during the 3 years of the trials, especially in the BWE area. Summaries of residues detected in birds, mammals, water, and sediment are presented in Tables 20-23.

The most obvious trend evident in the avian residue data is the shift from organophosphates. Except for a few samples containing toxaphene residues,

TABLE 20

AVIAN PESTICIDE RESIDUE SAMPLING SUMMARY[a]

1978

Area	No. Samples Taken	Positive Samples	Pesticide	High Residue	Mean Residue
OPM	117	2	parathion	0.120 ppm	0.003 ppm
CIC-MS	10	0	--	--	--
BWE	25	16	methyl parathion	0.477 ppm	0.061 ppm
		8	malathion	0.820 ppm	0.095 ppm
		3	toxaphene	7.040 ppm	0.430 ppm
CIC-NC[b]	5	1	malathion	0.310 ppm	0.062 ppm

1979

Area	No. Samples Taken	Positive Samples	Pesticide	High Residue	Mean Residue
OPM	98	4	methyl parathion	0.830 ppm	0.019 ppm
		3	chlorpyrifos	0.237 ppm	0.005 ppm
CIC-MS	20	0	--	--	--
BWE	75	1	chlorpyrifos	0.300 ppm	0.004 ppm
CIC-NC[b]	18	3	chlorpyrifos	8.330 ppm	0.506 ppm

1980

Area	No. Samples Taken	Positive Samples	Pesticide	High Residue	Mean Residue
OPM	80	28	fenvalarate	0.025 ppm	0.002 ppm
		6	chlordimeform	0.016 ppm	0.001 ppm
		11	permethrin	0.011 ppm	0.000 ppm
CIC-MS	17	3	fenvalarate	0.001 ppm	0.000 ppm
		3	permethrin	0.007 ppm	0.001 ppm
BWE	90	15	chlordimeform	0.264 ppm	0.014 ppm
		11	permethrin	0.006 ppm	0.000 ppm
CIC-NC[b]	11	1	permethrin	0.001 ppm	0.000 ppm

[a] Collection of samples was supervised by APHIS personnel. Samples were analyzed for pesticide residues at the NMRAL, Gulfport, Mississippi.

[b] Cleveland and Gaston Counties, North Carolina.

TABLE 21

MAMMALIAN PESTICIDE RESIDUE SAMPLING SUMMARY[a]

1978

Area	No. Samples Taken	Positive Samples	Pesticide	High Residue	Mean Residue
OPM	35	2	methyl parathion	0.988 ppm	0.037 ppm
		16	malathion	0.126 ppm	0.015 ppm
CIC-MS	4	0	--	--	--
BWE	1	0	--	--	--
CIC-NC[b]	0	--	--	--	--

1979

Area	No. Samples Taken	Positive Samples	Pesticide	High Residue	Mean Residue
OPM	23	0	--	--	--
CIC-MS	6	0	--	--	--
BWE	18	0	--	--	--
CIC-NC[b]	10	0	--	--	--

1980

Area	No. Samples Taken	Positive Samples	Pesticide	High Residue	Mean Residue
OPM	20	3	permethrin	0.031 ppm	0.002 ppm
		1	chlordimeform	0.004 ppm	0.000 ppm
		2	fenvalarate	0.003 ppm	0.000 ppm
CIC-MS	4	0	--	--	--
BWE	5	0	--	--	--
CIC-NC[b]	9	1	fenvalarate	0.001 ppm	0.000 ppm
		1	methyl parathion	0.003 ppm	0.000 ppm

[a] Collection of samples was supervised by APHIS personnel. Samples were analyzed for pesticide residues at the NMRAL, Gulfport, Mississippi.

[b] Cleveland and Gaston Counties, North Carolina.

TABLE 22

WATER PESTICIDE RESIDUE SAMPLING SUMMARY [a]

1978

Area	No. Samples Taken	Positive Samples	Pesticide	High Residue	Mean Residue
OPM	20	0	--	--	--
CIC-MS	0	0	--	--	--
BWE	0	0	--	--	--
CIC-NC[b]	4	0	--	--	--

1979

Area	No. Samples Taken	Positive Samples	Pesticide	High Residue	Mean Residue
OPM	25	0	--	--	--
CIC-MS	0	0	--	--	--
BWE	5	0	--	--	--
CIC-NC[b]	6	0	--	--	--

1980

Area	No. Samples Taken	Positive Samples	Pesticide	High Residue	Mean Residue
OPM	36	2 1	methyl parathion chlordimeform	0.009 ppm 0.001 ppm	0.000 ppm 0.000 ppm
CIC-MS	0	0	--	--	--
BWE	0	0	--	--	--
CIC-NC[b]	6	0	--	--	--

[a] Collection of samples was supervised by APHIS personnel. Samples were analyzed for pesticide residues at the NMRAL, Gulfport, Mississippi.

[b] Cleveland and Gaston Counties, North Carolina.

TABLE 23

SEDIMENT PESTICIDE RESIDUE SAMPLING SUMMARY[a]

1978

Area	No. Samples Taken	Positive Samples	Pesticide	High Residue	Mean Residue
OPM	20	0	--	--	--
CIC-MS	0	-	--	--	--
BWE	0	-	--	--	--
CIC-NC[b]	4	0	--	--	--

1979

Area	No. Samples Taken	Positive Samples	Pesticide	High Residue	Mean Residue
OPM	29	0	--	--	--
CIC-MS	0	-	--	--	--
BWE	5	0	--	--	--
CIC-NC[b]	12	0	--	--	--

1980

Area	No. Samples Taken	Positive Samples	Pesticide	High Residue	Mean Residue
OPM	36	31	chlordimeform	0.040 ppm	0.010 ppm
		3	azinphos-methyl	1.302 ppm	0.040 ppm
CIC-MS	0	-	--	--	--
BWE	0	-	--	--	--
CIC-NC[b]	12	10	chlordimeform	0.025 ppm	0.007 ppm
		4	azinphos-methyl	0.187 ppm	0.032 ppm

[a] Collection of samples was supervised by APHIS personnel. Samples were analyzed for pesticide residues at the NMRAL, Gulfport, Mississippi.

[b] Cleveland and Gaston Counties, North Carolina.

only residues of organophosphate insecticides were detected in the trial areas in 1978 and 1979. Many of the 1980 avian samples had nondetectable residues. Those positive 1980 samples showed very low mean residue levels of permethrin, chlordimeform, and fenvalarate.

The mammalian samples collected in the OPM trial area also demonstrated a shift from the organophosphates in 1978 to very low quantities of permethrin, fenvalarate, and chlordimeform in 1980. No residues were detected in mammal samples collected in the BWE or CIC areas in 1978 or 1979. Likewise, no residues were detected in mammals collected for BWE and CIC-MS in 1980; fenvalarate and methyl parathion were found in very low levels in a couple of samples for CIC-NC.

There were no water samples collected in 1978 or 1979 that contained detectable insecticide residues. There were no acceptable sites located in Pontotoc County, Mississippi, to collect water samples for the CIC strategy. Similarly, no water samples were taken in 1978 or 1980 for the BWE strategy. Of the water samples collected for OPM in 1980, only a couple showed trace levels of chlordimeform and methyl parathion.

Like the water samples, there were no pesticide residues detected in the sediment samples collected in 1978 and 1979. Sediment samples taken from the OPM and CIC-NC trial areas in 1980 contained residues of azinphos-methyl and chlordimeform.

Several points can be made about the residue data summarized here. The first is that all the residues detected were relatively low, especially in the 1980 samples. The second is that there has been a marked shift away from the appearance of the organophosphate insecticides in the samples collected in 1980 and an increase in the number of samples containing very low residues of

permethrin and chlordimeform. The possibility also exists that the pesticide residues actually resulted from insecticide use on crops other than cotton. This is especially true of the avian and mammalian samples, where species might move freely among different crops.

Despite the fact that many of the insecticides used for boll weevil control are toxic to fish, the chances of inadvertent application to surface waters are low, and the most heavily used insecticides, the organophosphates, are sufficiently short-lived to prevent them from entering waterways via runoff in dangerous quantities. The residue data gathered by APHIS in 1978, 1979, and 1980 appear to support this and do not indicate that any of the boll weevil control strategies had any significant adverse impacts on the environment within the trial areas.

ENVIRONMENTAL EVALUATION OF ALTERNATIVE BELTWIDE PROGRAMS

INTRODUCTION

This section presents the findings of the environmental evaluation of the proposed Beltwide Boll Weevil/Cotton Insect Management Programs. The environmental evaluation deals with the beltwide implementation of three major control alternatives, the continuation of current insect controls, optimum pest management, and boll weevil eradication. The three programs analyzed are technically termed CIC, OPM with incentives (OPM-I), and OPM with eradication (OPM-BWE). For the sake of simplicity, they will continue to be referred to throughout this report as CIC, OPM, and BWE, respectively.

Because of time and cost constraints, detailed pesticide residue transport and distribution (T&D) modeling was conducted on only 3 of 15 representative river basins, namely the Santee in South Carolina, the Flint in Georgia, and the

portion of the Red in northern Louisiana. Due to report delivery time frames, only the results from the detailed analysis are presented in this report. However, the environmental evaluation of the remaining 12 river basins revealed no significant changes from the evaluation of the Santee, Flint, and Red, and the evaluation results can be found in Attachment M.

Using the residue values obtained by the T&D calculations, the EEP methodology analyzes eight aspects of environmental concern: nontarget agriculture, aquatic life (includes fish farms and hatcheries), wildlife, endangered and threatened species, human ingestion, research conflicts, and social perception of the programs.

The analysis of environmental effects of any pest control program involving the use of chemical control agents must begin with a detailed definition of the control program components. In order to formulate the initial inputs to the models and analyses, information is required on the number of acres receiving treatment, the chemical formulations to be used, the number and frequency of applications, and the date of the first application. This information is given in Tables 24-26 for the CIC, OPM, and BWE programs respectively.

The program information for the CIC and OPM programs was provided by the Economic Evaluation Team (EET) and comes from the EET Delphi survey, except the number of applications which were calculated on a river basin average basis using information developed by Cooke[32/] on current beltwide control practices. All control program data were reported by EET production subregions and, as such, are weighted averages for the region. With respect to the Santee, Flint, and Red river basins, production subregions 5, 6, 7, 8, 9, 21, and 22 are represented. While there may well be deviations within each production subregion, information is not available at levels lower than this.

TABLE 24

CIC CONTROL PROGRAM DATA

EET Subregion Number	Cotton Acreage	Acre Treatments	Appl. Rate (lb/ac)	Appl. Frequency[a]	1st Appl. Date[b]	No. of Appl.
Methyl Parathion						
5	147,312	636,084	0.634	0.10	140	4.68
6	16,574	75,166	0.669	0.10	140	4.68
7	23,860	108,245	0.669	0.10	140	12.50
8	81,753	697,027	0.645	0.17	185	12.50
9	174,539	1,441,449	0.684	0.17	185	12.50
21	427,170	2,002,149	0.546	0.17	185	12.50
22	76,362	304,362	0.549	0.17	185	5.54
Methomyl						
5	147,312	5,825	0.47	0.04	200	1.0
6	16,574	0	0	0	0	0
7	23,868	0	0	0	0	0
8	81,753	27,739	0.112	0.17	211	1.3
9	174,539	60,278	0.121	0.17	211	1.3
21	427,170	23,217	0.5	0.04	190	1.0
22	76,362	4,839	0.5	0.04	190	1.0

TABLE 24 (Continued)

CIC CONTROL PROGRAM DATA

Permethrin

EET Subregion Number	Cotton Acreage	Acre Treatments	Appl. Rate (lb/ac)	Appl. Frequency[a]	1st Appl. Date[b]	No. of Appl.
5	147,312	806,915	0.102	0.14	205	1.85
6	16,574	50,204	0.1	0.14	205	1.85
7	23,868	72,298	0.1	0.14	205	6.04
8	81,753	459,512	0.102	0.17	185	6.04
9	174,539	981,115	0.111	0.17	185	6.04
21	427,170	832,715	0.11	0.17	185	0.72
22	76,362	231,210	0.111	0.17	185	0.72

[a] One application per number of days (e.g., 0.17 = one application per 6 days)

[b] Days are numbered consecutively from 1 to 365

TABLE 25

OPM CONTROL PROGRAM DATA

EET Subregion Number	Cotton Acreage	Acre Treatments	Appl. Rate (lb/ac)	Appl. Frequency[a]	1st Appl. Date[b]	No. of Appl.
			Methyl Parathion			
5	147,312	597,482	0.540	0.10	140	4.68
6	16,574	51,837	0.650	0.10	140	4.68
7	23,868	74,650	0.650	0.10	140	12.50
8	81,753	360,665	0.593	0.17	185	12.50
9	174,539	730,930	0.613	0.17	185	12.50
21	427,170	2,002,149	0.526	0.17	185	5.64
22	76,362	286,006	0.523	0.17	185	5.64
			Methomyl			
5	147,312	484	0.5	0.04	200	1
6	16,574	0	0	0	0	0
7	23,868	0	0	0	0	0
8	81,753	0	0	0	0	0
9	174,539	0	0	0	0	0
21	427,170	7289	0.5	0.04	190	1
22	76,362	4116	0.5	0.04	190	1

TABLE 25 (Continued)
OPM CONTROL PROGRAM DATA

Permethrin

EET Subregion Number	Cotton Acreage	Acre Treatments	Appl. Rate (lb/ac)	Appl. Frequency[a]	1st Appl. Date[b]	No. of Appl.
5	147,312	954,765	0.103	0.14	205	1.85
6	16,574	65,126	0.10	0.14	205	1.85
7	23,868	93,787	0.10	0.14	205	6.04
8	81,753	549,077	0.102	0.17	185	6.04
9	174,539	1,150,077	0.103	0.17	185	6.04
21	427,170	768,212	0.110	0.17	185	0.72
22	76,362	234,331	0.133	0.17	185	0.72

[a] One application per number of days (e.g., 0.17 = one application per 6 days)

[b] Days are numbered consecutively from 1 to 365

TABLE 26

BWE CONTROL PROGRAM DATA

EET Subregion Number	Cotton Acreage	Appl. Rate (lb/ac)	Appl. Frequency[a]	1st Appl. Date[b]	No. of Appl.
Malathion					
5	156,474	1	0.09	241	7
6	19,303	1	0.09	241	7
7	35,446	1	0.09	241	7
8	92,612	1	0.09	241	8
9	111,104	1	0.09	241	9
21	434,690	1	0.09	241	9
22	77,565	1	0.09	241	9
Diflubenzuron					
5	39,119	0.06	0.14	150	4
6	4,826	0.06	0.14	150	4
7	8,862	0.06	0.14	150	4
8	23,143	0.06	0.14	150	4
9	27,776	0.06	0.14	150	4
21	108,672	0.06	0.14	150	4
22	19,391	0.06	0.14	150	4

TABLE 26 (Continued)

BWE CONTROL PROGRAM DATA

Azinphos-methyl

EET Subregion Number	Cotton Acreage	Appl. Rate (lb/ac)	Appl. Frequency[a]	1st Appl. Date[b]	No. of Appl.
5	39,119	0.25	----	187	1
6	4,826	0.25	----	187	1
7	8,862	0.25	----	187	1
8	23,143	0.25	----	187	1
9	27,776	0.25	----	187	1
21	108,672	0.25	----	187	1
22	19,391	0.25	----	187	1

[a] One application per number of days (e.g., 0.14 = one application per 7 days)

[b] Days are numbered consecutively from 1 to 365

However, the values provided by the EET Delphi survey are indicative of expected practices over respective production subregions as a whole.

"Acre Treatments" attempts to compensate for variations in target, number of treatments, and rate of application for a given pesticide. Such variations arise because a pesticide will often be used over the same area both singly and in combination with other pesticides to control a variety of pest complexes. "Application Frequency" is expressed as the decimal equivalent of the frequency ratio. For example, one application every 6 days is expressed as 0.17. The column headed "1st Application Date" simply expresses dates as being numbered consecutively from 1 to 365. Hence, day number 140 corresponds to May 20.

The information for evaluation of the BWE program was obtained from Brazzel.[33/] Acre treatments values were not available for the BWE program. In addition, the form of the information required the assumption that all cotton acres were treated uniformly in terms of the number of applications. While this generally would not be true, it was impossible to specify local differences based on the available information.

TRANSPORT AND DISTRIBUTION

The purpose of the Transport and Distribution module is to provide estimates of the time-varying residues of pesticide on or in close proximity to the target site, as well as estimates of the time-varying concentrations associated with the various components of aquatic systems which drain the treatment area and surrounding land. These estimates must be made in such a way that they meet as nearly as possible the information needs of the other modules, subject to the constraints of available data and other resources. The pesticide residue calculations, runoff predictions, and stream routing analyses are presented for the Santee, Flint, and Red systems. An analysis of possible effects which

could occur on a more local basis is also presented in terms of two scenarios, i.e., small stream directly draining treated cottonfields and a farm pond receiving runoff from treated fields.

The CIC and OPM programs themselves are very similar, utilizing the same chemicals, except that the levels of application are expected to be somewhat less under the OPM program than under the CIC program. Consequently, the expected pattern of concentrations in receiving waters is very similar, except that it is scaled down slightly for the OPM program.

The BWE program specifies different chemicals than the CIC or OPM programs, at different application rates and under a different schedule. The chemicals themselves also have different properties, notably degradation rates. These factors affect residue levels expected in treated fields and resulting stream loadings. However, the configuration of the treated cotton acreage, the stream systems, and the hydraulics are all assumed to remain the same, so that the pattern of residues expected throughout the stream systems generally should be the same across programs.

Average pesticide residues in the soil of treated fields resulting from the three programs and concentrations of pesticides predicted by PESTRA (See Attachment H for illustrated examples of PESTRA output) are presented below for each of the river basins modeled. For the BWE program, the pesticide residues in the soil apply to all three river basins, since the program specified the same treatment rate and schedule for each.

Santee River Basin. Average pesticide residues expected in the soil of treated fields as a result of the CIC program are shown in Figure 3. Significant methyl parathion residues are shown from late May until September, peaking at just over 0.9 pound per acre in late June.

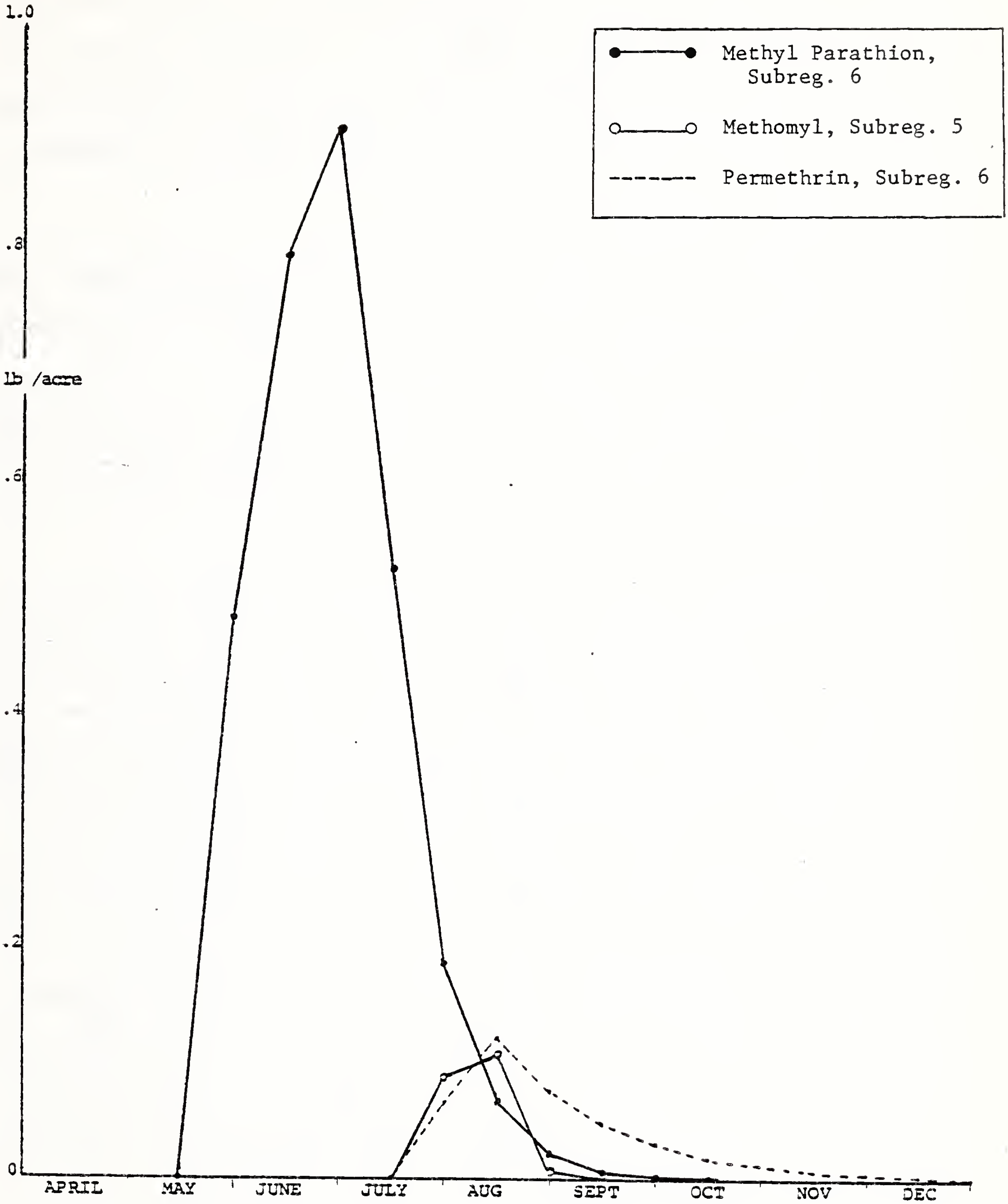


FIGURE 3. PESTICIDE RESIDUES IN THE SOIL CIC PROGRAM, SANTEE BASIN

Methomyl and permethrin residues are first expected in late July, and both peak in early August at over 0.1 pound per acre. The methyl parathion and permethrin data refer to subregion 6, which includes most of the river basin, but the methomyl data refers to subregion 5 because there is no signficiant methomyl usage in subregion 6.

The concentrations of methyl parathion from the CIC program predicted by PESTRA for the Catawba, Broad, and Saluda subbasins do not exceed 0.1-0.2 ug/liters. As pointed out earlier, the maximum values are expected only for a few small tributaries. Methomyl is not expected to occur in significant concentrations in any of the three segments, and permethrin concentrations are not expected to exceed 0.1 ug/liter.

For the OPM program, residues in the soil of methyl parathion are expected to follow the same pattern through time as for the CIC program, except that the OPM values are only 97 percent as great. Methyl parathion would be used on significantly fewer acres under OPM. Neither methomyl nor permethrin residues will be significantly different between the two programs within the treated fields. However, the total acreage treated with methomyl will be somewhat less under the OPM program, while permethrin will be used on more acres under OPM.

Methyl parathion concentrations from the OPM program predicted by PESTRA for the Catawba subbasin do not reach 0.2 ug/liter, and those for the Saluda and Broad subbasins do not reach 0.1 ug/liter. Significant concentrations of methomyl are not expected, and permethrin concentrations will not reach 0.1 ug/liter in any of the subbasins.

The average insecticide residues expected in the soil of treated fields as a result of the BWE program are shown in Figure 4. The actual timing of the applications might be expected to vary somewhat between regions as a result of

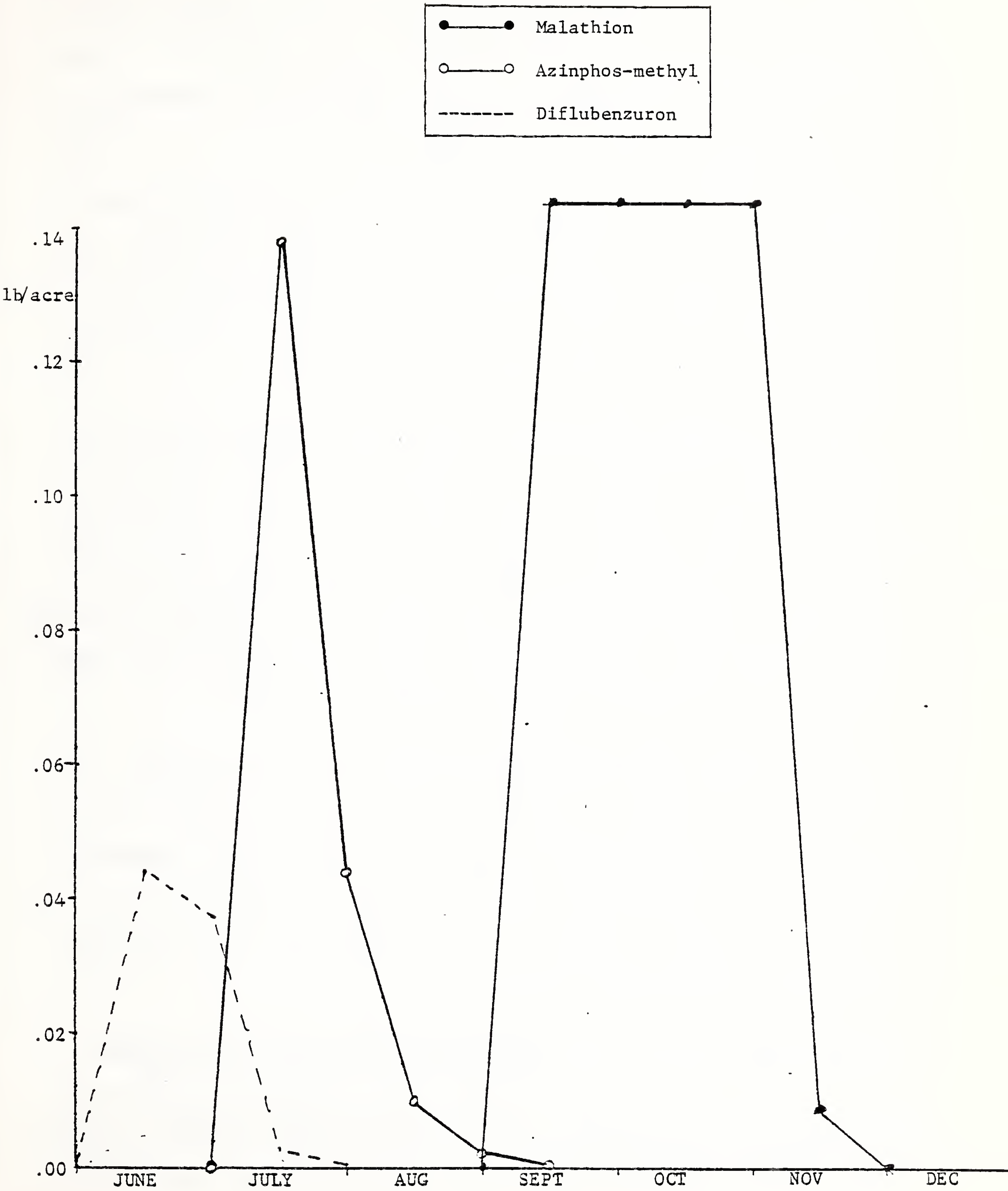


FIGURE 4. PESTICIDE RESIDUES IN THE SOIL--BWE PROGRAM

climatic differences. Malathion, azinphos-methyl and diflubenzuron concentrations peak at 0.144, 0.138, and 0.045 pound per acre, respectively. Azinphos-methyl has the longest half-life of the three chemicals but is expected to be nearly completely degraded by mid-September.

Malathion concentrations from the BWE program predicted by PESTRA are at a maximum for part of the Catawba subbasin at 0.46 ug/liter. Malathion predictions are less than 0.2 ug/liter for the Saluda and less than 0.3 ug/liter for the Broad subbasin. Neither diflubenzuron nor azinphos-methyl concentrations are expected to reach 0.1 ug/liter.

Flint River Basin. Average pesticide residues expected in the soil of treated fields of the Flint river basin (Region 9) as a result of the CIC program are shown in Figure 5. Methyl parathion residues are predicted from early July through November, peaking at over 1.6 pounds per acre in late September. Permethrin residues are also expected to occur primarily from early July through November, peaking in early August at 0.35 pound per acre. Minor (<0.04 lb./acre) methomyl residues are expected during August.

The yearly pattern of expected pesticide movement into the Flint River resembles the pattern of soil residues except that the shape of the peaks are changed slightly as the erosion potential changes with expected rainfall and crop coverage. The resulting concentrations of methyl parathion, methomyl, and permethrin predicted by PESTRA for the Flint River never reach 0.1 ug/liter even with the peak pesticide input.

Methyl parathion residues in the soil from the OPM program are expected to follow the same pattern through time as for the CIC program, but application rates are only 90-98 percent as great for the OPM program. Methyl parathion would be used on considerably fewer acres under OPM. Methomyl would not be

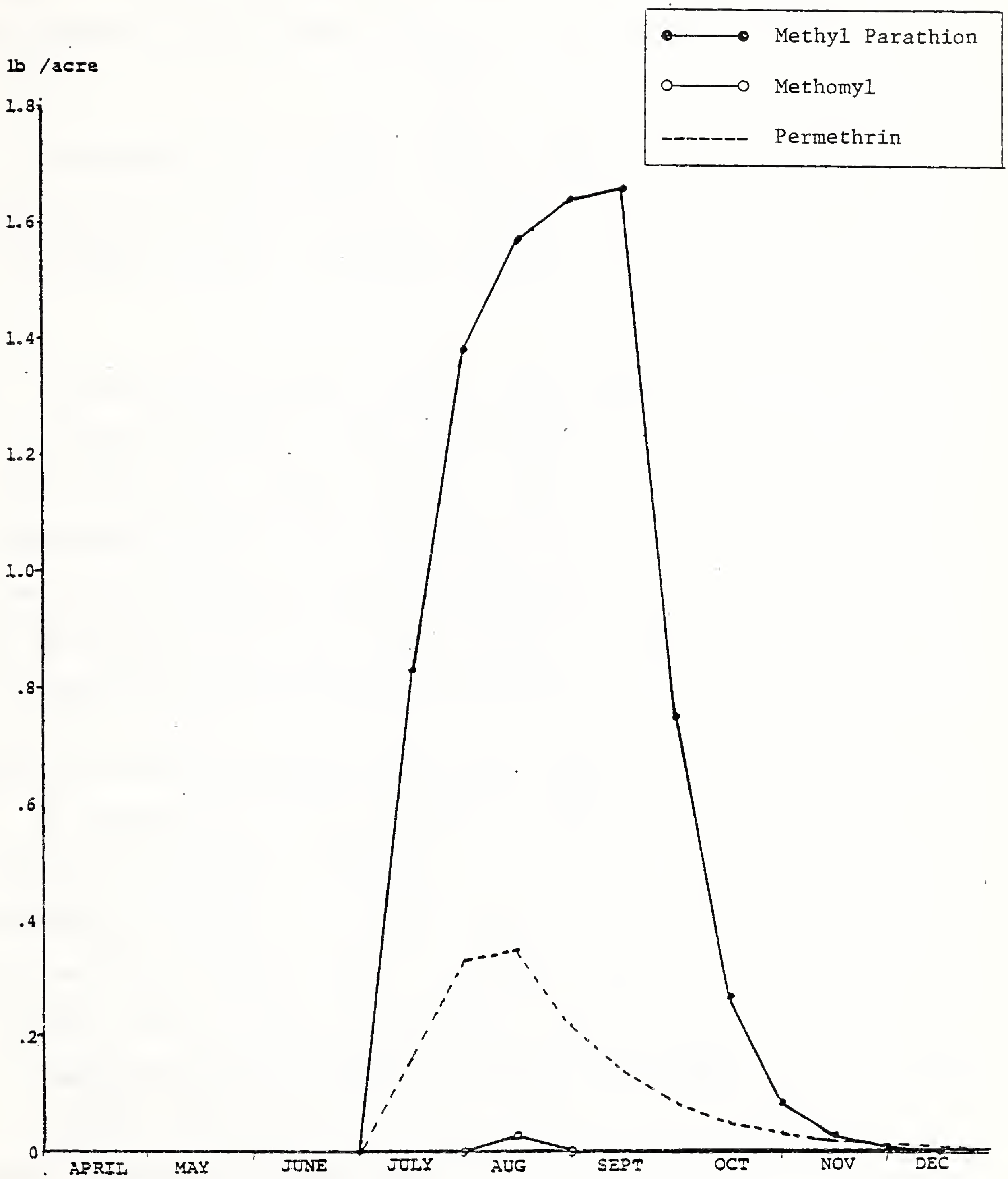


FIGURE 5. PESTICIDE RESIDUES IN THE SOIL CIC PROGRAM, FLINT RIVER BASIN, SUBREGION 9

used in the Flint river basin under OPM, while permethrin would be used on a somewhat larger acreage under OPM than CIC. Residues of permethrin in those fields which are treated are expected to remain essentially the same under the two programs.

Concentrations of the pesticides from OPM in the Flint River predicted by PESTRA are always less than 0.1 ug/liter. Similarly, none of the concentrations of the pesticides from the BWE program are expected to reach 0.1 ug/liter in the Flint River.

Red River Basin. Average pesticide residues expected in the soil of treated fields of Region 22 in the Red river basin as a result of the CIC program are shown in Figure 6. Methyl parathion residues are at significant levels from early July to October, reaching 1.1 pounds per acre in late July. Methomyl residues extend from early July into August, reaching 0.1 pound per acre at the maximum. Permethrin residues begin around July, reaching only 0.06 pound per acre during July and have nearly degraded by the end of September.

Concentrations of methyl parathion predicted by PESTRA for the Red river system as a result of the CIC program are as high as 27 ug/liter for tributary streams. The highest value is for parts of segment 05 along Black Bayou and McCain Creek. As discussed previously, these values represent a coincidence of very low flow and high loading conditions. At normal flows, these values would be lowered by more than two orders of magnitude, even with the peak loading assumption. The concentrations of methyl parathion predicted for the main stream of the Red River do not reach 0.1 ug/liter even under the extreme assumptions. Methomyl concentrations would only reach 0.2 ug/liter for segment 05 under these assumptions and would not exceed 0.1 ug/liter elsewhere. Maximum permethrin concentrations predicted were 14 ug/liter for segment 05 but never reached 0.1 ug/liter in the Red River proper.

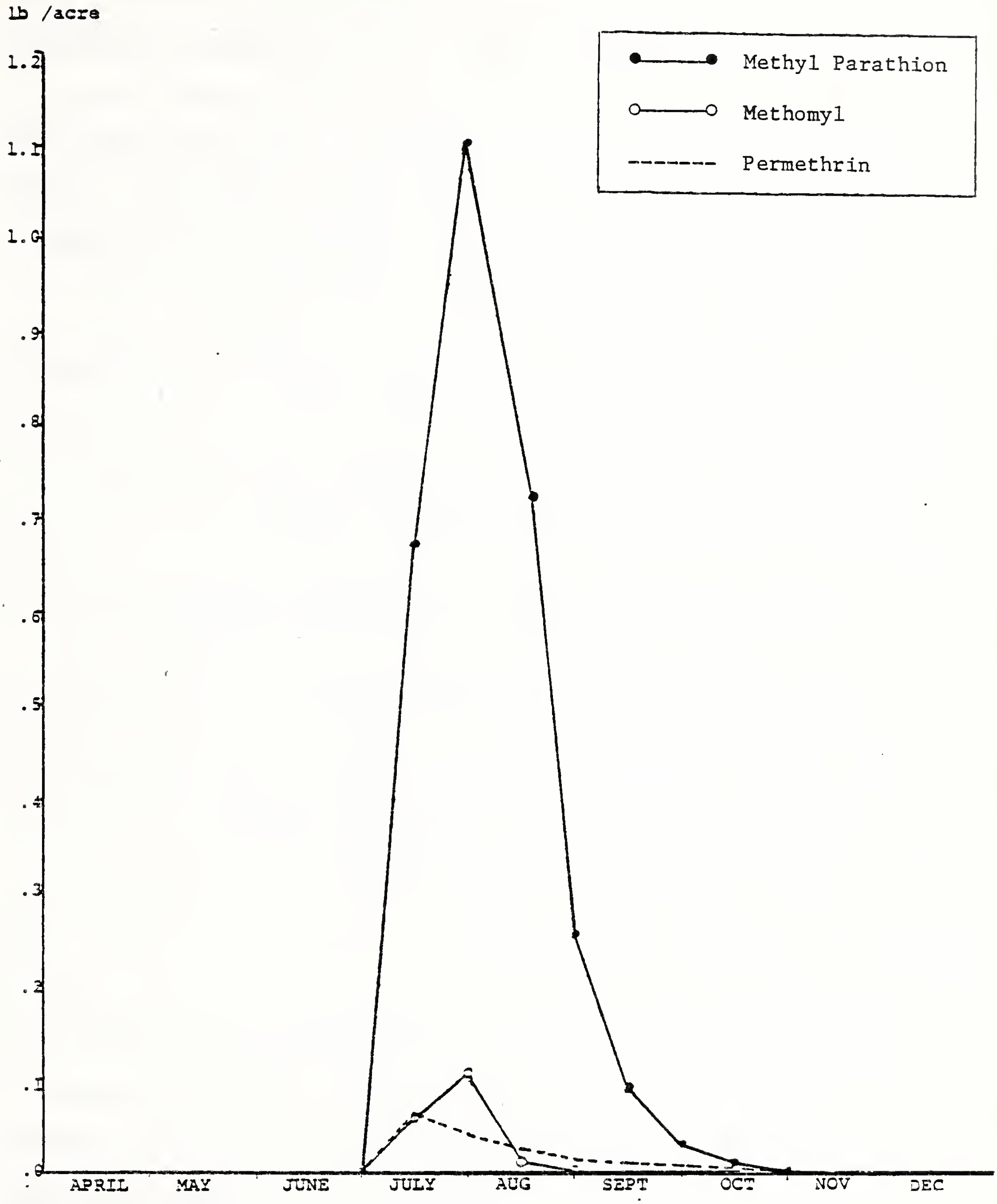


FIGURE 6. PESTICIDE RESIDUES IN THE SOIL CIC PROGRAM, RED RIVER BASIN, SUBREGION 22

Methyl parathion residues in the soil of treated fields in the Red river basin are expected to be about 5 percent less under the OPM program than under the CIC program. The total acreage to be treated is nearly the same. Methomyl soil residues are expected to be the same under the two programs, except that less than half the acreage would be treated under OPM as under CIC. Residues of permethrin are also expected to remain the same under the two programs, except that slightly less acreage would be treated under OPM.

Concentrations of methyl parathion and methomyl predicted for the streams of the Red river basin are generally a few percent less under OPM than under the CIC program. However, concentrations of permethrin are expected to be approximately 15 percent greater under OPM than under CIC.

As with the other two programs, higher concentrations of pesticides are predicted for Red River tributaries at low flow in the BWE program. The highest levels are estimated in segment 05, where 114 ug/liter of malathion is predicted by PESTRA. However, in the main stream of the Red River, concentrations do not exceed 0.4 ug/liter. The other two chemicals follow the same pattern. Diflubenzuron concentrations at a maximum of 6.2 ug/liter and azinphos-methyl concentrations at a maximum of 32 ug/liter are predicted in segment 05.

Local Scenarios. The preceding sections discussed the methodology and some of the results of a modeling scheme which is intended to aid in the analysis of potential effects of pesticide applications over large drainage areas. However, the highest concentrations of pesticide can be expected to occur in small areas in the immediate vicinity of treated fields. These pesticide concentrations are also liable to be very transient.

Two scenarios are examined to illustrate the possible magnitude of such local concentrations. Actual conditions, of course, are quite variable across the

Cotton Belt, but the scenarios constitute a worst case for use as a baseline in the analysis. The results can be scaled to approximate other situations.

The first scenario consists of a small stream directly draining treated cottonfields. In this case, the concentration of pesticides in the stream would be the same as that in runoff leaving the fields. After the stream water leaves the treated area, pesticide concentrations would rapidly decrease.

Wauchope[43/] has reviewed published reports of pesticide concentrations in runoff waters as they leave agricultural fields and used this information to derive an empirical expression for the prediction of worst-case concentrations. The concentration predicted, C_t, represents the highest which might be expected to occur in the event of an erosive rainstorm at time t after application. The predictive equation is as follows:

$$C_t = R\ A\ (1 + 0.44t)^{-1.6}$$

where: A = availability index in $\frac{\text{ug-ha}}{\text{liter-kg}}$

R = application rate in kg/ha, and

t = number of days after application.

Figure 7 shows the predicted C_t for methyl parathion, methomyl, and permethrin at their highest rate of use in the CIC program. For each of these chemicals, A has been assumed to be 300 on the basis of the information given by Wauchope. It can be estimated that a storm immediately after application could produce 228, 167, or 37 ug/liter of methyl parathion, methomyl, or permethrin, respectively. Ten days later this would be reduced to 15.4, 11.2, and 2.5 ug/liter, respectively.

A similar situation could be predicted for the OPM program, except that the acreages of concern have changed somewhat, and the application rates have

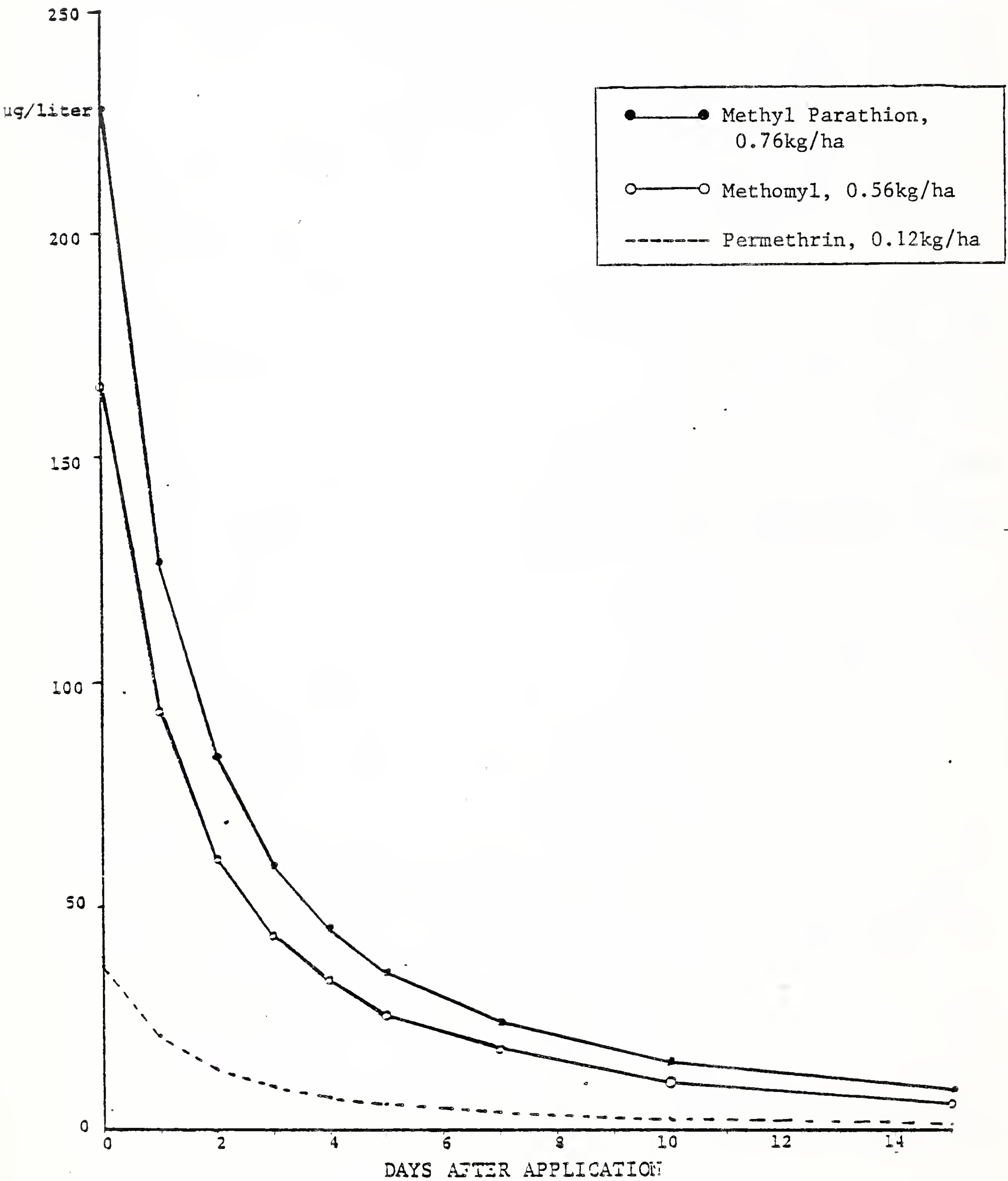


FIGURE 7. WORST-CASE CONCENTRATIONS (C_t) OF PESTICIDES AT FIELD EDGE - CIC PROGRAM

changed slightly in some instances. The concentrations of pesticide calculated for the scenarios are directly proportional to application rates.

For the BWE program, the worst-case concentration estimates for a small stream directly draining treated cottonfields are shown in Figure 8. It predicts that malathion concentration in runoff, in the case a storm immediately after application, may be 300 ug/liter, but under these same circumstances, azinphos-methyl concentrations are not likely to exceed 75 ug/liter, nor diflubenzuron concentrations to exceed 18 ug/liter. The risk rapidly diminishes with time.

The second scenario consists of a farm pond receiving runoff from treated fields. The pond is assumed to cover 1 acre, with an average depth of 4 feet, draining a 100 acre area, half of which is treated cotton. Loadings for the pond were calculated for each chemical based on the pesticide runoff predictions of the program USLE. Pesticide runoff per acre of cotton was calculated for the area and 2-week time period of greatest risk. A pesticide delivery ratio of 50 percent was used. The resulting estimates of pesticide inputs and diluted concentrations in the pond are shown in Table 27.

TABLE 27

FARM POND SCENARIO - PESTICIDE INPUTS AND CONCENTRATIONS

Chemical	Tons Delivered to Pond	Concentration in Pond (ug/liter)
Methyl Parathion	1.25×10^{-3}	256.0
Methomyl	7.55×10^{-6}	1.6
Permethrin	4.15×10^{-4}	85.1
Malathion	1.25×10^{-3}	256.0
Azinphos-methyl	2.86×10^{-4}	58.0
Diflubenzuron	1.85×10^{-4}	38.0

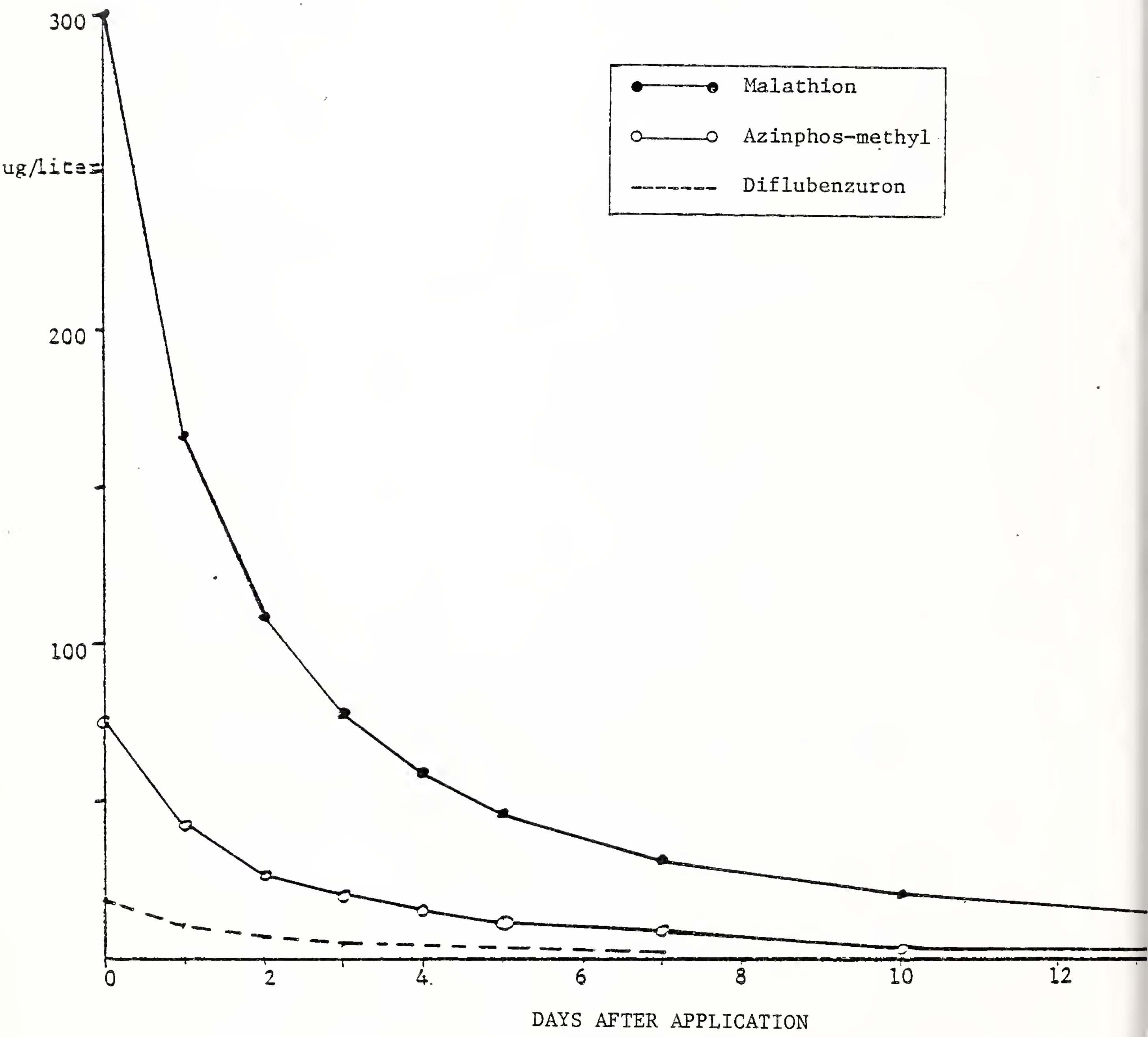


FIGURE 8. WORST-CASE CONCENTRATIONS (C_t) OF PESTICIDES AT FIELD EDGE - BWE PROGRAM

Wauchope[43], in a review of research on the pesticide content of surface water draining from agricultural fields, stated that for the majority of commercial pesticides, total losses over time are no more than 0.5 percent of the amount applied, except for when unusual rainstorm events occur soon after application. As an independent check on the loadings presented in Table 27, the same scenario was reexamined using the rule of thumb estimate of 0.5 percent loss of applied chemicals. The resulting estimate of the concentration of methyl parathion or malathion in the pond is 100 ug/liter, assuming that all of the chemical lost from the field reaches the pond. This concentration is 39 percent of that predicted in Table 27. However, if the pond is at all removed from the contributing cottonfield, then a delivery ratio would have to be applied.

For the farm pond scenario, we can conclude that only under very rare circumstances would concentrations of pesticide exceed 100 ug/liter. The scenario analysis can be directly scaled to other situations by considering changes in the chemical application rate, the contributing acreage, pond size, and the delivery ratio.

NONTARGET AGRICULTURE

The objective of the Nontarget Agriculture module is to estimate the effects a pesticide program will have on nontarget or offsite agriculture by characterizing and quantifying adverse impacts on:

- nontarget food and feed crops,
- domestic livestock and poultry, and
- commercial bee (honey, packaged bees and queens, and wax) production.

Information on pesticide spray drift following application is the primary input into this module along with:

- pesticide fate in the environment,
- including half-life on vegetation,
- crop distribution and acreage,
- pesticide toxicity, and
  animal feeding studies.

The "EPA-Holst" spray drift model was adapted especially for quantifying drift onto nontarget acreage for use in this module. A detailed documentation of this drift model can be found in KTR 194-80 (Attachment G). The results of the drift model application are reported in acreage distributions over five levels of pesticide residues. The estimated mean pesticide residue was then calculated as the product of the incremental acreage distributions and pesticide residue classes divided by the total acreage of that crop in the river basin.

Impacts on food and feed crops, domestic livestock and poultry, honey, packaged bees and queens and wax production were evaluated by comparing the mean pesticide residue levels on each crop with phytotoxicity information, U.S. residue tolerances on or in raw agricultural commodities, domestic animal diet information, mammalian and avian toxicity studies, and animal feeding studies.

This analysis resulted in the calculation of mean residue levels in food crops and livestock and poultry products which were then used as inputs into the Human Ingestion module.

The nontarget crops considered in the offsite assessment were limited to the major agricultural crops of each river basin for which acreage data on a county basis was available. Table 28 provides a listing by river basin of crops which were assessed for adverse impact from phytotoxicity and residue accumulation.

TABLE 28

CROPS CONSIDERED IN THE NONTARGET AGRICULTURE MODULE FOR EACH RIVER BASIN

River Basins		
Santee Crop (acreage x 100)	Flint Crop (acreage x 100)	Red Crop (acreage x 100)
Corn (32.3)	Corn (340.5)	Corn (8.0)
Wheat (19.9)	Wheat (29.2)	Wheat (4.2)
Oats (16.4)	Soybeans (277.6)	Sorghum (4.5)
Barley (11.4)	Peanuts (191.6)	Soybeans (328.7)
Rye (1.9)	Sorghum (16.6))	Sugar Cane (3.9)
Hay (92.9)	Pasture (407.2)	Rice (3.0)
Sorghum (8.1)		Pasture (541.4)
Soybeans (167.4)		
Apples (0.8)		
Peaches (15.7)		
Pasture (459.5)		

The breeds and diets of dairy cows in each of the three river basins are very similar. A composite diet was used to calculate dietary exposure levels. That diet consisted of, on a daily basis, approximately:

- 75 lb. silage,
- 10 lb. hay, and
- 20 lb. protein mixture (corn grain, soybean meal, and cottonseed meal).

Corn silage is used more often as feed, but sorghum was substituted in the diet calculations because a mean residue level was not available for corn

vegetation. The protein mix considered consisted of 15 pounds corn and 5 pounds soybean meal. The mean residue level for each diet component used in the calculations was always the upper value of the residue range. Daily dietary exposure was calculated as the product of the amount consumed and the mean residue level divided by the animal's weight.

Beef cattle across the South have similar diets and weigh on the average around 1,100 pounds. Breeds vary, however, from basin to basin. The predominant breeds are Brahman, Hereford, and Angus. Most of the beef cattle operations are open range grazing with the cattle's diet supplemented in winter with grain and silage. Since the control programs would be operating from spring to late summer, the affected diet is considered to consist totally of pasture grasses. The dietary calculations for cattle used a daily average intake of 95 pounds of grasses (wet) per day per animal.

Dietary exposure for chickens (broilers) was determined from information collected on diet and average broiler size. The diet of an average broiler consists of approximately 0.11 pound of corn and 0.03 pound of soy meal per day along with vitamin supplements. The diet is approximately uniform across the river basins. Most poultry raising operations are the confinement type where the broilers are kept indoors for the 8 weeks they are held before slaughter.

Tables 29-31 show the calculated daily dietary exposure from the three programs for livestock and poultry in the Santee, Flint, and Red river basins.

Each control program was evaluated separately via the methodology of the nontarget agriculture model with each basin reviewed as a distinct entity within each program.

TABLE 29

DAILY DIETARY EXPOSURE FROM THE CIC PROGRAM FOR LIVESTOCK AND POULTRY IN THE SANTEE, FLINT, AND RED RIVER BASINS

River Basin Animals	Pesticide Dietary Intake (mg/kg of body weight/day)		
	Methyl Parathion	Methomyl	Permethrin
Santee River Basin			
Dairy Cows	0.0002	0.000001	0.00002
Beef Cattle	0.0013	<0.000001	0.002
Poultry - broilers	0.00006	0.000001	0.00008
Flint River Basin			
Dairy Cows	0.0002	0.00004	0.0004
Beef Cattle	0.0016	0.0005	0.0042
Poultry - broilers	0.00009	0.00001	0.0002
Red River Basin			
Dairy Cows	0.0009	0.00007	0.0017
Beef Cattle	0.0081	0.0011	0.0242
Poultry - broilers	0.00024	0.000014	0.00035

TABLE 30

DAILY DIETARY EXPOSURE FROM THE OPM PROGRAM FOR LIVESTOCK AND POULTRY IN THE SANTEE, FLINT, AND RED RIVER BASINS

River Basin Animals	Pesticide Dietary Intake (mg/kg of body weight/day)		
	Methyl Parathion	Methomyl	Permethrin
Santee River Basin			
Dairy Cows	0.0001	<0.000001	0.0003
Beef Cattle	0.0009	<0.000001	0.0026
Poultry - broilers	0.000045	<0.000001	0.000097
Flint River Basin			
Dairy Cows	0.0001	0	0.0002
Beef Cattle	0.0007	0	0.0048
Poultry - broilers	0.00044	0	0.00017
Red River Basin			
Dairy Cows	0.0009	0.00006	0.0021
Beef Cattle	0.0073	0.0009	0.0269
Poultry - broilers	0.00023	0.000009	0.00037

TABLE 31

DAILY DIETARY EXPOSURE FROM THE BWE PROGRAM FOR LIVESTOCK AND POULTRY IN THE SANTEE, FLINT, AND RED RIVER BASINS

River Basin Animals	Pesticide Dietary Intake (mg/kg of body weight/day) Diflubenzuron	Azinphos-methyl	Permethrin
Santee River Basin			
Dairy Cows	0.00007	0.00006	0.0012
Beef Cattle	0.0007	0.0003	0.0044
Poultry - broilers	0.00001	0.000009	0.00024
Flint River Basin			
Dairy Cows	0.00006	0.00004	0.0011
Beef Cattle	0.007	0.0002	0.0044
Poultry - broilers	0.000015	0.00001	0.0003
Red River Basin			
Dairy Cows	0.0003	0.0002	0.0061
Beef Cattle	0.0052	0.0019	0.0208
Poultry - broilers	0.00003	0.00002	0.00063

Current Insect Control:

Santee River Basin. The upper Santee river basin encompasses portions of four South Carolina agricultural districts; northwest, north central, west central, and central. These areas produce thousands of acres of cotton, hay, and grain crops along with apples and peaches. Dairy and beef cattle, broilers, layers, and bees are the major domestic animal species raised commercially in these districts. The nontarget effects of pesticide spray drift from the CIC program had to be limited to the major agricultural commodities for which sufficient information was available.

The mean residue ranges on food and feed in the Santee are presented in Table 32. The mean residue range is the range in concentration of pesticide residues drifting on crops immediately following the first spray application to the last application in the program. The residues on the crops, excluding pasture, are all less than a 0.01 ppm. The lowest established U.S. tolerance for methyl parathion and methomyl on food and feed crops is 1 ppm. Established tolerances for permethrin are almost exclusively for livestock and poultry products. Residues from permethrin are taken into consideration in the livestock and poultry impact analysis. Mean residues on pasture are less than 1 ppm. No tolerance per se has been established on pasture. Therefore, tolerances on clover, alfalfa, and similar pasture type crops were used. These vary from 1-10 ppm. The highest mean residue level on pasture is 0.015 ppm for methyl parathion. Methomyl residues on pasture are <0.0001 ppm. The mean residue levels are well below U.S. tolerance; there is no expected loss from crops being withheld from the marketplace because of residues in excess of tolerances.

Methyl parathion is registered for use on apples, barley, corn, oats, peanuts, peaches, rice, rye, sorghum, soybeans, wheat, and pastures at application rates

TABLE 32

CIC PROGRAM — SANTEE RIVER BASIN - ESTIMATED MEAN RESIDUE LEVELS (ppb) ON TOTAL CROP IMMEDIATELY FOLLOWING SINGLE SPRAY TREATMENT AND AFTER THE FINAL TREATMENT

	Pesticide Residues (ppb)		
Crop	Methyl Parathion	Methomyl	Permethrin
Corn	0.68 - 0.70	0.01 - a	0.54 - 0.99
Wheat	0.65 - 0.67	b	0.61 - 1.12
Oats	0.64 - 0.66	b	0.61 - 1.12
Barley	0.48 - 0.50	0.00 - a	0.37 - 0.68
Rye	0.87 - 0.90	b	1.04 - 1.91
Hay	8.55 - 8.83	0.04 - a	5.06 - 9.31
Sorghum	1.67 - 1.72	0.00 - a	0.93 - 1.71
Soybeans	4.74 - 4.89	0.08 - a	3.45 - 6.35
Apples	1.12 - 1.16	0.00 - a	0.68 - 1.25
Peaches	1.02 - 1.05	0.00 - a	1.11 - 2.04
Pasture	14.30 - 14.76	0.07 - a	12.82 - 23.60

[a] only one treatment

[b] crop harvested prior to spraying

of 0.25 to 2 pounds actual per acre. The application rate of methyl parathion for the CIC program ranges from 0.63 to 0.67 pound a.i. per acre in the Santee. It is not phytotoxic when applied at recommended rates. However, injury has been reported on alfalfa and sorghum; the rate which caused damage was not reported.[44/] It does not seem likely that spray drift from cottonfields would cause damage to any of the crops that have been considered.

Methomyl is also used on many of the crops considered in the assessment, such as apples, corn, peanuts, and soybeans at the rate of 0.225 to 0.9 pound a.i. per acre. It is applied in the CIC program at a rate of 0.47 pound a.i. per acre. Methomyl is not phytotoxic when used as directed.[44/] Damage from CIC program spray drift is unlikely, especially since recommended application rates in practice on many crops are equal to or greater than those of the CIC program.

Permethrin is not phytotoxic when used as directed. Recommended application rates are 0.05 to 2 pounds a.i. per acre. It is being tested for use on some of the crops we have considered such as corn, soybeans, and apples. It is applied at a rate of 0.1 pound a.i. per acre in the CIC program. Therefore, no damage to crops is expected.

From the calculated exposure values shown in Table 32, it was concluded that the CIC program would result in no hazard to dairy or beef cattle since the daily dietary intakes are far below known effect levels. All three insecticides would be rapidly eliminated from the body through metabolism and urinary or feces excretion and elimination. No significant amount would be expected to remain or accumulate in the body. Also, none of these chemicals would be expected to produce significant residues in milk at the levels estimated from the dietary exposure calculations since the dietary exposure is so low and the chemicals are quickly eliminated from the body.

Comparing the low dietary exposure predicted for each of the chemicals in the CIC program and the nonaccumulation and rapid elimination, significant residues in broilers or eggs would not be expected.

Methyl parathion and methomyl individually are highly toxic to bees. However, when methyl parathion is combined with methomyl, the overall toxic effect on bees is increased. The CIC program calls for methomyl applications approximately 15 days after methyl parathion; therefore, a synergistic reaction is not expected.

Beekeepers in the Santee river basin were contacted to determine the current practices and precautions taken to avoid bee kills. Many beekeepers avoid placing their hives near cottonfields because they have experienced, at times, anywhere from minor damage to severe loss from sprayings. However, none of the beekeepers could identify the chemicals which had caused damage. Covering or moving hives away from cottonfields at times of spraying were cited as ways of protecting hives. Those beekeepers who chose to place their hives near cottonfields felt the economic gain from this location outweighed losses. A State bee inspector contacted had no complaints regarding bee loss from cotton spraying in the "last couple of years." He noted that encapsulated parathion used in spraying peach trees was causing most bee kills in this area.

Other precautions which could be undertaken in the spray program to minimize losses are:

- spray in the afternoon or evening so that the morning activity of the bees will not be affected,
- use spray formulations, not dust, and
- use ground application mechanisms rather than aerial applications,[45/] when applicable.

Flint River Basin. The Flint river basin is an important producing area for several major agricultural commodities, including grains, peanuts, poultry, dairy products, and vegetables.

The mean pesticide residue levels on food and feed crops in the Flint river basin are presented in Table 33. The highest mean residue level on any crop, excluding pasture, was 0.016 ppm of permethrin on soybeans. U.S. tolerances for permethrin have been established for only livestock and poultry products, so that comparisons of mean residue levels on crops with tolerances are not possible for permethrin. The mean residue levels of methyl parathion and methomyl on pasture are 0.018 ppm and 0.006 ppm, respectively. These are well below the U.S. tolerances for grasses, forage, or hay. No mean residue levels approached or exceeded crop tolerances.

Many of the crops considered in the nontarget impact assessment are themselves treated with the same pesticides utilized in the CIC program. These pesticides are not phytotoxic when used as directed. The recommended rates of application on crops are 0.25 to 2, 0.255 to 0.9, and 0.05 to 2 pounds a.i. per acre for methyl parathion, methomyl, and permethrin, respectively. Those used in the CIC program are 0.67, 0.12, and 0.11 pound a.i. per acre.

Daily dietary intake levels for dairy and beef cattle, presented in Table 33 are extremely low. As with the Santee livestock exposures, no observable effects would be expected, and significant residue levels would not be expected to appear in meat or milk.

Similarly, no observable effects would be expected in poultry-broilers at these dietary levels, and no significant residues would be expected in meat or eggs.

TABLE 33

CIC PROGRAM — FLINT RIVER BASIN - ESTIMATED MEAN RESIDUE LEVELS (ppb) ON TOTAL CROP IMMEDIATELY FOLLOWING SINGLE SPRAY TREATMENT AND AFTER THE FINAL TREATMENT

	Pesticide Residues (ppb)		
Crop	Methyl Parathion	Methomyl	Permethrin
Corn	0.58 - 0.66	0.03 - 0.04	0.23 - 0.98
Wheat	0.87 - 0.99	a	0.48 - 2.05
Sorghum	2.91 - 3.32	0.43 - 0.58	1.42 - 6.07
Soybeans	8.20 - 9.37	1.11 - 1.50	3.67 - 15.68
Peanuts	0.23 - 0.26	0.04 - 0.05	0.68 - 1.29
Pasture	15.71 - 17.95	4.38 - 5.93	12.82 - 48.98

[a] crop harvested prior to spraying

The effect on the bee industry will be very much the same as that noted for the Santee. Beekeepers contacted in the Flint river basin reported reservations about keeping bees near cottonfields. Those who had kept their hives near cottonfields reported losses from spraying on cottonfields. Toxaphene was the only chemical related to cotton spraying identified as causing bee kills. Most beekeepers reported keeping hives away from cottonfields as the best way to avoid spray related damage. Bee loss has also been reported from spraying corn, vegetables, and peaches. Estimates of losses ranged from $100 to $300 for replacement of bees without quantifying losses from honey reduction and wax quality or production.

Red River Basin. The food and feed crops considered in the nontarget impact analysis are listed in Table 28. These represent the crops for which enough information was available for modeling and which were considered prominent because of their acreage contributions. Dairy and beef cattle, broilers, layers, and bees were considered for the impact on domestic animals.

The mean residue levels on crops in the Red river basin are presented in Table 34. The highest mean residue level on crops, excluding pasture, for the CIC program in the Red river basin was calculated on soybeans for permethrin at 0.033 ppm. As noted previously, tolerances for permethrin have been set for livestock and poultry products, exclusively. Its residue contribution, therefore, is primarily considered in the livestock and poultry impact analysis. The highest mean residue levels for methyl parathion and methomyl were found on soybeans at 0.023 ppm and 0.002 ppm, respectively. These are well below the established U.S. tolerances of 0.1 ppm for methyl parathion and 0.2 ppm for methomyl. Pasturage would receive mean residues of 0.094 ppm and 0.013 ppm of methyl parathion and methomyl. These mean residue levels are also well below established tolerance levels.

TABLE 34

CIC PROGRAM — RED RIVER BASIN - ESTIMATED MEAN RESIDUE LEVELS (ppb) ON TOTAL CROP IMMEDIATELY FOLLOWING SINGLE SPRAY TREATMENT AND AFTER THE FINAL TREATMENT

	Pesticide Residues (ppb)		
Crop	Methyl Parathion	Methomyl	Permethrin
Corn	1.89 - 2.16	0.05 - a	3.09 - a
Wheat	3.00 - 3.43	b	7.27 - a
Sorghum	11.54 - 13.19	1.10 - a	26.18 - a
Soybeans	20.19 - 23.07	1.69 - a	33.23 - a
Rice	1.35 - 1.54	0.11 - a	3.48 - a
Sugarcane	0.43 - 0.49	0.04 - a	1.09 - a
Pasture	82.16 - 93.90	13.21 - a	280.72 - a

[a] only one treatment

[b] crop harvested prior to spraying

As stated for the Santee and Flint river basins, many of the crops considered for offsite impact in the Red river basin are themselves treated with methyl parathion, methomyl, and permethrin at application rates above those used in the CIC program. No crop damage, therefore, is expected on any of the considered crops from either residue accumulation or phytotoxicity in the Red river basin from the CIC program.

In the Red river basin, as in the Santee and Flint river basins, the size and diet of dairy cows and beef cattle are approximately uniform within breeds. From the diet information and approximate size of dairy and beef cattle, daily dietary exposure levels were calculated.

Toxic effects would not be expected in dairy cows at the levels of pesticide intake shown in Table 29. Residues in milk resulting from these levels in dairy cows would not be significant.

Beef cattle are grazed on open range (pasture for the most part) during the time the CIC program is conducted. At the expected low intake levels, there would be no observable effect of the CIC program on beef cattle. The residue levels on pasture would not remain long after the last application of pesticide. Methyl parathion has a 2-day half-life on exposed foliage, methomyl is slightly longer at 4 days, and permethrin is more persistent at 28 days. The residue levels would be decreased substantially within 2 weeks of the last treatment. The residue levels used in the calculations are worst-case residues for animals grazing over both affected and nonaffected lands. The intake levels are also well below mammalian toxicity levels. The residues in beef calculated from dietary intake would be <10 ppb, and would be considered insignificant.

Likewise, the pesticide levels calculated for poultry are well below any avian toxicity levels. Residues in eggs would be far below the tolerances established for residues of permethrin (the only pesticide of the three for which a tolerance has been established for livestock and poultry products) and insignificant to the calculation of human ingestion.

Beekeepers contacted in the Red river basin reported bee kills and loss in honey production from various crop spray programs. Some keep hives near cottonfields, but generally try to keep them at least 1/4 mile away. None reported taking special precautions during times of spraying.

Optimum Pest Management:

Santee River Basin. The food and feed crops, livestock, and poultry considered in the nontarget analyses of the CIC program were also used for the OPM program. Mean residue levels on each crop and daily dietary exposure levels were calculated, substituting OPM program characteristics for CIC characteristics.

Mean residue levels on the considered crops are reported in Table 35. None of the mean residue levels approaches to an established tolerances. Methomyl mean residues are <0.01 ppb on the considered crops. The highest mean residue level on pasture (permethrin residues are considered in the livestock and poultry analysis) was 0.01 ppm for methyl parathion.

None of the chemicals used in the OPM program are phytotoxic when used as directed on the label. The rates used in the OPM program are all within the recommended levels, hence no damage to any of the nontarget crops is predicted.

TABLE 35

OPM PROGRAM — SANTEE RIVER BASIN - ESTIMATED MEAN RESIDUE LEVELS (ppb) ON TOTAL CROP IMMEDIATELY FOLLOWING SINGLE SPRAY TREATMENT AND AFTER THE FINAL TREATMENT

	Pesticide Residues (ppb)		
Crop	Methyl Parathion	Methomyl	Permethrin
Corn	0.56 - 0.58	0.00 - a	0.66 - 1.21
Wheat	0.50 - 0.52	0.00 - a	0.75 - 1.38
Oats	0.50 - 0.52	0.00 - a	0.75 - 1.38
Barley	0.34 - 0.36	0.00 - a	0.47 - 0.86
Rye	0.74 - 0.76	0.00 - a	1.25 - 2.30
Hay	5.92 - 6.11	0.00 - a	6.46 - 11.89
Sorghum	1.13 - 1.17	0.00 - a	1.21 - 2.23
Soybeans	3.51 - 3.62	0.01 - a	4.25 - 7.82
Apples	0.76 - 0.78	b	0.88 - 1.62
Peaches	0.70 - 0.72	0.00 - a	1.44 - 2.65
Pasture	9.79 - 10.11	0.01 - a	16.46 - 30.30

[a] only one treatment

[b] no pesticide applied

The intake levels shown in Table 30 for dairy cows are well below any which would be expected to cause toxic effects or residues in milk.

Beef cattle intake levels are all below those which would result in any observable effects or significant residues in meat.

The intake levels in poultry are also far below those which would be expected to cause significant residues in meat or eggs.

As stated for CIC, methyl parathion and methomyl are highly toxic to bees. Unprotected hives near cottonfields would probably experience losses. Losses could be mitigated in the OPM program if the same procedures outlined for the CIC program were implemented.

Flint River Basin. The food and feed crops and domestic animals considered in the OPM program in the Flint are the same as those considered for the CIC program.

The mean residue levels on food and feed crops as calculated from the drift modeling output are reported in Table 36. The mean residue levels calculated for methyl parathion on crops were well below the U.S. tolerances. Methomyl was not applied in the Flint river basin. No losses from residue levels on crops exceeding tolerances are anticipated. No damage from phytotoxicity is expected.

From Table 30, it can be seen that the OPM program in the Flint, like the Santee, would result in no observable effects to dairy cows, beef cattle, or broilers. No significant residues would be expected to accumulate in meat, milk, or eggs.

The effect on the apiaries in the Flint river basin from the OPM program would be very much the same as for the CIC program.

TABLE 36

OPM PROGRAM — FLINT RIVER BASIN - ESTIMATED MEAN RESIDUE LEVELS (ppb) ON TOTAL CROP IMMEDIATELY FOLLOWING SINGLE SPRAY TREATMENT AND AFTER THE FINAL TREATMENT

Crop	Pesticide Residues (ppb)		
	Methyl Parathion	Methomyl	Permethrin
Corn	0.28 - 0.32	a	0.27 - 1.15
Wheat	0.42 - 0.48	a	0.55 - 2.35
Sorghum	1.37 - 1.57	a	1.59 - 2.52
Soybeans	3.88 - 4.43	a	4.10 - 17.52
Peanuts	0.11 - 0.13	a	0.33 - 1.41
Pasture	7.47 - 8.54	a	12.94 - 55.30

[a] no pesticide applied

Red River Basin. The food and feed crops, livestock, and poultry identified and analyzed for adverse impacts from drift are the same for the OPM program as those considered in the CIC program. The mean residue levels in crops in the Red river basin are presented in Table 37.

It was calculated that soybeans would receive the highest mean residue levels on crops, excluding pasture. Mean residue levels were 0.021 and 0.001 ppm for methyl parathion and methomyl, respectively. These levels are well below the established U.S. tolerances. There are no tolerances for permethrin established on crops. Mean residue levels on pasture are also well below the tolerances established on pasture crops.

No phytotoxicity is anticipated if insecticides are applied at rates within those recommended on the label.

Table 30 shows that intake levels in diary cows, beef cattle, and poultry are not high enough to cause observable effects or significant residues in meat, milk, or eggs.

Some bee losses could be predicted for hives kept near cottonfields. As stated earlier, losses could be mitigated by taking precautions. The beekeeper must consider the risks when hives are placed near cotton in order to benefit from the long blooming season.

Boll Weevil Eradication:

Santee River-Basin. The food and feed crops, livestock, and poultry species considered for impact from the BWE program were the same as those considered for the OPM and CIC programs. Mean residue levels and dietary exposure levels were calculated for each crop and animal using information provided from the BWE runs of the drift modeling.

TABLE 37

OPM PROGRAM -- RED RIVER BASIN - ESTIMATED MEAN RESIDUE LEVELS (ppb) ON TOTAL CROP IMMEDIATELY FOLLOWING SINGLE SPRAY TREATMENT AND AFTER THE FINAL TREATMENT

	Pesticide Residues (ppb)		
Crop	Methyl Parathion	Methomyl	Permethrin
Corn	1.74 - 1.99	0.04 - a	3.33 - a
Wheat	2.73 - 3.12	0.19 - a	7.96 - a
Sorghum	10.34 - 11.82	0.89 - a	29.38 - a
Soybeans	18.69 - 21.36	1.01 - a	35.17 - a
Rice	1.21 - 1.38	0.10 - a	3.86 - a
Sugarcane	0.39 - 0.45	0.03 - a	1.21 - a
Pasture	73.58 - 84.10	10.70 - a	311.61 - a

[a] only one treatment

Mean residue levels calculated for diflubenzuron, azinphos-methyl, and malathion on the considered crops appear in Table 38. These mean residue levels were compared with the established U.S. tolerances for raw agricultural commodities. The calculated mean residue levels for diflubenzuron could not, however, be compared with the U.S. tolerances because they are set for livestock and poultry products only.

The mean residue levels of azinphos-methyl and malathion were found to be well below the U.S. tolerances.

Diflubenzuron is not phytotoxic at recommended rates of 0.02 to 0.14 pound actual per acre. It would be applied at 0.06 pound a.i. per acre in the BWE strategy. Damage to crops from drift, therefore, is not likely.

Azinphos-methyl has been reported to have caused injury to some fruit varieties; however, no other crops seem to be affected. The recommended rate of application is 4-6 pounds on many crops, including apples, barley, oats, pastures, peaches, rye, soybeans, sugarcane, and wheat.[44/] The rate used in the BWE program would be 0.25 pound per acre. Fruit damage would not be expected to occur at this application rate, and even less likely to occur as a result of drift from the BWE program.

Malathion has been found to cause injury to McIntosh and Cortland varieties of apples. These varieties, however, are not grown in Spartanburg County, the only county within the three river basins where appreciable acreage of apples exist. The recommended application rate for malathion on apples is 0.5 to 3 pounds actual per acre. Because only 1 pound per acre is applied in the BWE program, no damage is expected.

From the literature review of feeding studies and the results presented in Table 31, it is concluded that the pesticide intake from the BWE program in the

TABLE 38

BWE PROGRAM — SANTEE RIVER BASIN - ESTIMATED MEAN RESIDUE LEVELS (ppb) ON TOTAL CROP IMMEDIATELY FOLLOWING SINGLE SPRAY TREATMENT AND AFTER THE FINAL TREATMENT

	Pesticide Residues (ppb)		
Crop	Diflubenzuron	Azinphos-methyl	Malathion
Corn	0.03 - 0.09	0.06 - a	1.74 - 1.91
Wheat	0.08 - 0.23	0.06 - a	1.68 - 1.84
Oats	0.08 - 0.23	0.06 - a	1.66 - 1.82
Barley	0.06 - 0.18	0.04 - a	1.24 - 1.36
Rye	0.11 - 0.32	0.08 - a	2.23 - 2.45
Hay	1.10 - 3.22	3.05 - a	45.52 - 49.93
Sorghum	0.16 - 0.47	0.36 - a	8.18 - 8.97
Soybeans	0.40 - 1.17	0.96 - a	21.42 - 23.50
Apples	0.13 - 0.38	0.29 - a	2.85 - 3.13
Peaches	0.27 - 0.79	0.27 - a	2.64 - 2.90
Pasture	2.95 - 8.62	3.11 - a	46.50 - 51.01

[a] only one treatment

diet of dairy cows and beef cattle would not result in significant residues in milk or meat, or cause observable effects to the animals.

Similarly, significant residues are not expected in the meat or eggs of poultry because of the extremely low pesticide intake levels.

All three of the insecticides in the BWE program are toxic to bees. As stated before, certain precautions can be taken to lessen the impact from application of pesticides. As long as beekeepers place hives in proximity to cottonfields, losses can be expected to occur.

Flint River Basin. The same food and feed crops, livestock, and poultry species are considered as in the other two programs for the Flint river basin.

The mean residue levels for all three pesticides are presented in Table 39. None of the mean residue levels for either azinphos-methyl or malathion meets or exceeds established U.S. tolerances for raw agricultural commodities. Therefore, no losses from pesticide contamination of crops is anticipated.

None of the chemicals are phytotoxic to any of the considered crops. Hence, no losses are expected as a result of spray drift onto crops from the BWE program.

From the calculated daily intake levels presented in Table 31, no significant residues would be expected in livestock and poultry in the Flint resulting from the BWE program. None of the values were high enough to cause observable effects. Calculations made in the human ingestion analysis show that residues in milk and eggs from these feeding levels would be insignificant.

TABLE 39

BWE PROGRAM — FLINT RIVER BASIN - ESTIMATED MEAN RESIDUE LEVELS (ppb) ON TOTAL CROP IMMEDIATELY FOLLOWING SINGLE SPRAY TREATMENT AND AFTER THE FINAL TREATMENT

	Pesticide Residues (ppb)		
Crop	Diflubenzuron	Azinphos-methyl	Malathion
Corn	0.02 - 0.06	0.04 - a	1.25 - 1.37
Wheat	0.09 - 0.26	0.06 - a	1.86 - 2.04
Sorghum	0.23 - 0.67	0.50 - a	11.37 - 12.47
Soybeans	0.56 - 1.64	1.35 - a	30.23 - 33.16
Peanuts	0.02 - 0.06	0.02 - a	0.48 - 0.53
Pasture	2.75 - 8.40	29.1 - a	43.37 - 47.58

[a] only one treatment

In the Flint, as in the Santee, some losses to bees could be expected in the BWE program if the hives are placed near cottonfields. See earlier mitigating procedures and precautions.

Red River Basin. The food and feed crops, livestock, and poultry considered in the Red river basin for the BWE program are the same as those considered in the CIC and OPM programs.

The mean residue levels in crops resulting from the BWE program in the Red river basin are presented in Table 40.

The mean residue levels for azinphos-methyl and malathion on the considered crops were all well below the established U.S. tolerances. Drift from the BWE applications would not be expected to injure offsite crops.

Like the Santee and Flint, Table 31 shows no significant residues expected from the BWE program in dairy cows, beef cattle, and poultry in the Red river basin. The malathion figure is the highest intake level calculated, yet significant residues still would not be expected to occur in meat. No significant residues are expected to occur in milk or eggs.

Some losses due to the BWE program in the Red river basin are probable for bees if the hives are placed near cottonfields, unless appropriate precautions are taken.

AQUATICS

The Aquatics module is included in the evaluation methodology to provide direction for examining the impacts of insecticide use on aquatic organisms. The potential movement of insecticides from the target cottonfields, via drift, runoff, and leaching, and their toxicity to different aquatic organisms make the application of this module essential.

TABLE 40

BWE PROGRAM — RED RIVER BASIN - ESTIMATED MEAN RESIDUE LEVELS (ppb) ON TOTAL CROP IMMEDIATELY FOLLOWING SINGLE SPRAY TREATMENT AND AFTER THE FINAL TREATMENT

	Pesticide Residues (ppb)		
Crop	Diflubenzuron	Azinphos-methyl	Malathion
Corn	0.07 - 0.20	0.16 - a	4.65 - 5.10
Wheat	0.42 - 1.23	0.30 - a	8.75 - 9.60
Sorghum	1.37 - 4.00	3.00 - a	68.32 - 74.94
Soybeans	1.04 - 3.04	2.51 - a	56.18 - 61.63
Rice	0.22 - 0.64	0.16 - a	4.55 - 4.552
Sugarcane	0.07 - 0.20	1.03 - a	2.66 - 2.92
Pasture	20.77 - 60.73	21.96 - a	219.51 - 240.80

[a] only one treatment

The module includes a discussion of the aquatic environments of each of the three basins, a review of the insecticide residues predicted in the T&D module, the residues actually measured under field conditions, and a comparison of these values with those known to cause toxic response under laboratory or field conditions. A similar approach is taken in assessing the potential impacts of each program to the farm ponds and aquafarms found in these river basins. The module provides the following estimates:

- insecticide uptake and toxicity to aquatic organisms;
- effects on populations of aquatic organisms;
- residues in fish for input to the Human Ingestion module; and
- market losses due to closings of fishing areas or fish farms and impoundment of catch.

There are three major Aquatics module subsections, each addressing the impacts of CIC, OPM or BWE. Within each of the three subsections, the impacts specific to the Santee, Flint, and Red river basins are discussed separately. The first subsection, which addresses the CIC program, also contains necessary background information, including the characteristics of each basin's aquatic environments. The subsections relating to the OPM and BWE programs present only the results of the T&D modeling and the analysis of the potential impacts.

Current Insect Control:

Santee River Basin. The Santee river basin is one of 24 that make up the South Atlantic-Gulf drainage basin. The physiographic region in which the Santee is being studied is the Piedmont. Rivers in this drainage basin typically arise as mountain streams and become slower, and more turbid as they cross the Piedmont. After crossing the fall line and entering the Coastal

Plain, they continue to slow and broaden, but become less silted. Crossing the Piedmont and the Coastal Plain, the rivers also tend to become warmer, and their natural biota varies accordingly. These waters favor species capable of tolerating warmer temperatures, such as the cyprinids (minnows) and the centrarchids (sunfishes). While large, natural lakes are not common in the Santee River drainage area, there are a number of small, manmade farm ponds, typically fed by springs, small streams, and drainage runoff.

Rivers in the South Atlantic-Gulf basin generally have soft water, low pH, and high concentrations of organic acids. The surface waters of most of these rivers frequently have high sediment, nutrient, and pesticide inputs attributed to agriculture, silviculture, and municipal and industrial discharges.

The current pesticide residues in the Santee River were assessed for comparison with pesticide levels predicted for the CIC practices in the T&D module.

Data available in the Environmental Protection Agency's STORET file contains 348 water samples collected between 1975 and 1979 and analyzed for residues of malathion and azinphos-methyl. While these chemicals are not used in the defined CIC program, they are organophosphates and methyl parathion could be expected to have similar characteristics. Of these 348 samples (water and suspended solids), none contained residues greater than 0.1 ug/liter.

Other sources were contacted to determine the existence of data concerning the presence of detectable insecticide residues in fish found in the Santee River. To this end, data gathered by the South Carolina Department of Health and Environmental Control between 1974 and 1979 were the most useful. Malathion and methyl parathion were among the organophosphate insecticides for which each sample was screened. No residues of these two insecticides were detected in any samples during the 6 years of sampling.

Residue data were not available for any of the standing water habitats in the Santee river basin. However, as part of the ENET monitoring plan, APHIS personnel collected and screened water and sediment samples from ponds in Cleveland and Gaston Counties, North Carolina, an area using CIC techniques during the 3 trial years. Of the water and sediment samples collected, none contained detectable residues of methyl parathion, methomyl, and permethrin.

Table 41 summarizes the results of the T&D modeling of methyl parathion, methomyl, and permethrin in the Santee river basin. These values represent the maximum residues expected to occur in the water, according to the expected insecticide use as the CIC program is defined. These values are intended to provide an upper limit on the expected residues.

TABLE 41

MAXIMUM RESIDUES (COUPLED[a])
EXPECTED UNDER CIC PROGRAM (mg/liter)
IN THE SANTEE RIVER BASIN

Segment	Methyl Parathion	Methomyl	Permethrin
Catawba	0.0002	<0.0001	<0.0001
Saluda	<0.0001	<0.0001	<0.0001
Broad	0.0001	<0.0001	<0.0001

[a] "Coupled" is defined as that borne by suspended sediment particles and that released from the sediment into solution.

The results indicate that the maximum concentrations of methyl parathion, methomyl, and permethrin that could be reached in the Santee River system are very low. Methyl parathion appears in the highest concentration, and concentrations in all three tributaries are still much less than 1 ppb. While there is no data concerning the screening of waters of the Santee for residues of methyl parathion, the data retrieved from STORET showed no residues of malathion and azinphos-methyl (two other commonly used organophosphates)

greater than 0.1 ppb. This enables the data generated in the T&D module to be used as an upper value to the actual residues encountered in the field, which is consistent with the worst-case approach. Because there is a limited amount of data concerning the residues existing in the Santee River, it is impossible to draw definite conclusions about the relationship between the actual and predicted residues other than the upper bound function served by the predicted values. The evidence indicates that concentrations calculated in the T&D module should not be exceeded, but there is insufficient evidence to determine how much lower the existing values are, and under what conditions, if any, they approach the predicted worst-case values.

Concentrations of methyl parathion predicted in the T&D module for the Santee River were at least 100 times lower than those found to be toxic to the most sensitive fish. Crayfish are among the most sensitive aquatic organisms to the organophosphate insecticides (96-hr LC_{50} for methyl parathion = 3 ppb), and under worst-case conditions, the maximum estimated residues are at least 10 times lower than those necessary to cause acute toxic effects. Consequently, no negative impacts should result from the predicted introduction of methyl parathion into the Santee River from the CIC program.

Methomyl is less toxic to both fish and crustacea than is methyl parathion and the maximum concentrations expected to enter the Santee River are less than those expected for methyl parathion. The predicted concentrations of methomyl are less than 1/100th of those known to affect even the most sensitive aquatic organism. No adverse impacts are expected to result from the introduction of methomyl into the Santee River from the CIC program.

The predicted residues of permethrin are all less than 0.1 ppb. While levels as low as 0.15 ppb have been shown to affect aquatic insects under laboratory

conditions, the chemical's rapid disappearance in the field indicates that concentrations greater than this would be necessary to cause an impact. Therefore, no adverse effects are expected to result from the concentrations of permethrin predicted from the use of CIC techniques in the Santee river basin.

Scenarios of potential pesticide residues in standing water habitats were described in the T&D module. Under those assumed conditions, maximum residues of methyl parathion, methomyl, and permethrin would approach 0.26 mg/liter, 0.002 mg/liter and 0.085 mg/liter respectively. As these are based on pesticide sediment delivery quantities calculated as inputs to the PESTRA modeling, they are also worst-case estimates for the conditions assumed. They are maximum values based on the combination of weather conditions, pesticide application timing, vegetation cover, and cropping practices selected to result in the maximum pesticide movement. Therefore, predictions of residues of methyl parathion, methomyl, and permethrin that could exist in farm ponds similar to those described in the T&D module are greater than those predicted for the Santee River. This is understandable, as conditions described in those scenarios were worst-case estimates for particularly vulnerable systems. Even under such conditions, which could exist in the Santee river basin in isolated instances, predicted residues of methyl parathion and methomyl are less than the 96-hr LC_{50}'s of two sensitive centrarchids, the bluegill and largemouth bass. Also, the behavior of these insecticides in the environment makes it unlikely that any resulting mortality will be sufficient to cause more than temporary population declines in the most sensitive fish.

Permethrin has been shown to accumulate in channel catfish to levels 76 times those found in static water. However, the laboratory conditions under which these tests were made are greatly different than those existing in the environment. Permethrin is extremely short-lived in water, and aquatic organisms have been shown to quickly eliminate permethrin when returned to clean water.

Because data is not available on accumulation in the field, the laboratory study accumulation factor and the farm pond scenarios will be taken as a worst case. Consequently, under these worst-case conditions, maximum expected residues of permethrin in fish and crayfish tissue are estimated to be 76 times those in the pond water, or 6.5 ppm.

The owners and managers of the fish farms and hatcheries in the Santee were contacted and questioned about the effects that the use of insecticides to control cotton insects may have had on their facilities. There were few instances of cottonfields existing near these fish farms and there were no reports of kills caused by insecticides or of residues detected in the fish. It is very unlikely that organisms raised in these facilities would have residues equal to those described above in the farm pond scenario.

Flint River Basin. The Flint river basin, like the Santee, is a component of the South Atlantic-Gulf drainage basin. The segment of the Flint modeled in the T&D module includes the headwaters down to the Jim Woodruff Dam, and includes land in both the Piedmont and Coastal Plain physiographic regions. Farm ponds are common within this drainage area, but large, natural lakes are scarce.

While no data on insecticide residues in the waters of the Flint are available, there has been some work done to screen fish tissues for the presence of insecticides and polychlorinated biphenyls. While residues of other, more persistent insecticides were detected, no samples were found containing malathion or methyl parathion residues equal to or greater than the detection limits of 0.10 ppm.

There were no insecticide residues greater than 0.0001 mg/liter predicted for the water of the Flint River under the CIC strategy.

The predicted worst-case residues of methyl parathion, methomyl, and permethrin in the Flint River are below those known to cause significant effects to aquatic organisms. Except under very severe conditions, in isolated situations, no impacts are expected to be caused by insecticide use under CIC techniques in the Flint River system.

Possible effects on farm ponds similar to those whose scenarios are described as worst case situations in the T&D module are the same for the Flint as for the Santee river basin. As less cotton exists in this region (40,422 acres vs. 147,312 acres) the probability of this being encountered is less.

The managers of the fish farm and hatcheries in the Flint river basin were contacted and no kills or detectable pesticide residues were reported.

Red River Basin. The Red River crosses two water resource regions in Louisiana, the Arkansas-White-Red and the lower Mississippi. Approximately three-fourths of the basin, the northwestern portion, is included in the Arkansas-White-Red region and is made up of western Gulf Coastal Plain. The downstream portion of the river drains land of the Mississippi alluvial plain and is included in the lower Mississippi water resource region. The numerous tributaries that feed the Red River drain the majority of the northwest portion of the State of Louisiana.

The current pesticide load of the Red River was assessed for comparison with levels predicted in the T&D module. The Louisiana Water Quality Management Plan[46/] was the best source for this information. A summary of STORET data presented in this document shows that water and mud samples screened for malathion and methyl parathion rarely contained residues equal to or above the chemical's detection limits. Of 442 samples screened for malathion between

1973 and 1978, none contained detectable residues. Only a few samples (less than 10) contained residues of methyl parathion with the maximum residue detected being 0.09 ug/liter.

Table 42 summarizes the maximum residues of methyl parathion, methomyl, and permethrin expected to occur in the Red river basin, as predicted by the T&D module, under the CIC program.

TABLE 42

MAXIMUM RESIDUES (COUPLED[a]) EXPECTED UNDER CIC PROGRAM IN THE RED RIVER BASIN(mg/liter)

Segment	Methyl Parathion	Methomyl	Permethrin
1 and 3	0.0007	<0.0001	<0.0001
5	0.0265	0.0002	0.0142
9	0.0190	<0.0001	0.0098
11	0.0031	<0.0001	0.0009
13	0.0129	0.0001	0.0083
15	0.0047	<0.0001	0.0014
16	0.0028	<0.0001	0.0007
17	0.0049	<0.0001	0.0010
23	0.0073	<0.0001	0.0017
27	0.0004	<0.0001	<0.0001

[a] "Coupled" is defined as that borne by suspended sediment particles and that released from the sediment into solution.

While the methyl parathion residues are higher in the Red River than those predicted for either the Santee or the Flint, the maximum values are still less than 0.03 mg/liter. These predicted residues are in general agreement with actual residues found to exist in the river, in which a very low percentage of the samples contained detectable residues, and the maximum methyl parathion concentration detected was 0.09 ug/liter. This value is more than 300 times lower than the predicted maximum. Again, the predicted residues should be looked at as upper bounds of the residues of all three insecticides that could be expected under worst-case conditions.

The maximum residues predicted for methyl parathion are well below the concentrations known to cause mortality in all fish species tested, except the extremely sensitive mosquitofish (96 hr LC_{50} = 5 ppb). The maximum values predicted for Segments 5, 9, 13, and 23 are sufficiently high though to cause mortality in aquatic insects such as the water flea, Daphnia sp., crayfish, and other crustacea. As these predicted residue values are compared to concentrations toxic under laboratory conditions, which are usually lower than those found to cause mortality in the field, any mortality occurring should only affect the most sensitive aquatic crustacea and would be limited to the most vulnerable areas.

The maximum residues of methomyl predicted for the Red River are extremely low and no adverse impacts should result.

The predicted residues of permethrin are greater than those found to cause mortality in fish fry, crayfish, and aquatic insects under laboratory conditions. A field study conducted to test the effects of permethrin on aquatic organisms demonstrated that permethrin disappeared very rapidly from natural waters, and mortality was not nearly as prevalent as the laboratory studies would predict. Should the concentrations of permethrin predicted in the T&D module actually be reached in the Red River, some isolated cases of mortality of sensitive fish species, crayfish, and other crustacea could possibly occur. However, given the rapid disappearance of permethrin from the water, mortality would likely be very limited and confined to small areas, allowing for rapid recolonization by surviving organisms.

Under the farm pond scenario described in the T&D module, maximum tissue residues in fish and crayfish in the Red River are not expected to exceed those predicted for farm ponds in the Flint and Santee river basins. These are 0.26 ppm, 0.002 ppm, and 6.5 ppm for methyl parathion, methomyl, and permethrin.

The managers of the fish farms and hatcheries in the Red river basin were contacted. One minor fish kill was reported, but the actual date was not available. It was attributed to the use of toxaphene or endrin, or a mixture of the two (the manager was unsure of this). No residues were detected in the fish in later sampling and screening efforts. There were no indications that the use of methyl parathion, methomyl, and permethrin under a CIC program would affect the fish farms and hatcheries in the Red river basin.

Optimum Pest Management:

Santee River Basin. Table 43 summarizes the maximum residues of methyl parathion, methomyl, and permethrin expected to occur in the Santee river basin, as predicted by the T&D module, under the OPM program.

TABLE 43

MAXIMUM RESIDUES (COUPLED[a]) EXPECTED UNDER THE OPM PROGRAM
IN THE SANTEE RIVER BASIN (mg/liter)

Segment	Methyl Parathion	Methomyl	Permethrin
Catawba	0.0002	<0.0001	<0.0001
Saluda	<0.0001	<0.0001	<0.0001
Broad	<0.0001	<0.0001	<0.0001

[a] "Coupled" is defined as that borne by suspended sediment particles and that released from the sediment into solution.

The maximum residues expected to exist in the Santee River under the OPM program are very low. Residues of methyl parathion, methomyl, and permethrin are all much less than 1 ppb, lower than those concentrations known to cause mortality under laboratory conditions. Under certain extreme conditions, aquatic insects could be affected, but otherwise no impacts to the aquatic organisms of the Santee River are expected under the insecticide use pattern of the OPM program.

The use of insecticides in the OPM program in the Santee river basin is considerably lighter than estimates used in the farm pond scenarios presented in the T&D module. While it is possible that the use of insecticides in the OPM program would vary enough so that impacts to the organisms of a farm pond could be similar to those described under the CIC program, it is unlikely that this would occur.

It is not possible to determine how much lower the potential insecticide residues in fish and crayfish tissue might be, in comparison to those predicted for the CIC program. It is safe to say that they should not exceed these residues. For methyl parathion, methomyl, and permethrin, the upper limits were estimated to be 0.26 ppm, 0.002 ppm, and 6.5 ppm.

The same situation exists with the assessment of possible impacts to fish farms and hatcheries. No negative impacts were predicted or identified under the CIC program, so none are expected to occur from lighter use of the same insecticides under the OPM program.

Flint River Basin. There were no insecticide residues greater than 0.0001 mg/l predicted for the waters of the Flint River under the OPM program.

The maximum residues expected to occur in the Flint River under the OPM program are lower than those concentrations known to cause mortality under laboratory conditions to the most sensitive aquatic organisms. Consequently, no impacts to the aquatic organisms of the Flint River are expected under the insecticide use pattern of the OPM program.

The farm pond scenario for the Flint river basin is similar for the OPM and CIC programs. Again, tissue residues of methyl parathion, methomyl, and permethrin

are not expected to exceed 0.26 ppm, 0.002 ppm, and 6.5 ppm from the OPM program in the Flint river basin and these would persist for only very short times.

Since no impacts to fish farms and hatcheries have been identified under existing conditions, or were predicted under the proposed CIC insecticide use pattern, no effects are expected to be caused by very similar insecticide use under the OPM program.

Red River Basin. Table 44 summarizes the maximum residues of methyl parathion, methomyl, and permethrin expected to occur in the Red river basin, as predicted by the T&D module, under the OPM program.

TABLE 44

MAXIMUM RESIDUES (COUPLED[a]) EXPECTED UNDER THE OPM PROGRAM IN THE RED RIVER BASIN (mg/liter)

Segment	Methyl Parathion	Methomyl	Permethrin
1 and 3	0.0007	<0.0001	0.0001
5	0.0235	0.0002	0.0165
9	0.0168	0.0001	0.0117
11	0.0026	<0.0001	0.0011
13	0.0115	<0.0001	0.0100
15	0.0042	<0.0001	0.0126
16	0.0024	<0.0001	0.0009
17	0.0043	<0.0001	0.0012
23	0.0061	<0.0001	0.0021
27	0.0003	<0.0001	<0.0001

[a] "Coupled" is defined as that borne by suspended sediment particles and that released into solution.

The use of insecticides under the OPM program in the Red river basin is nearly identical to that of the CIC program, as are the results of the T&D modeling. Consequently, the impacts that were predicted for the CIC program in the Red river basin are also likely to be encountered under the OPM program. These include possible mortality of the fry of sensitive fish species, aquatic

insects, crayfish, and other crustacea in vulnerable areas under severe conditions, such as heavy runoff immediately following an application during a critical low flow period. Such mortality could be caused by either methyl parathion or permethrin residues, but given that each is short-lived, rapid repopulation by surviving organisms would be expected.

Similar conditions also exist with regard to the ponds described in the T&D module scenarios. Partial kills of sensitive aquatic organisms, primarily crustacea, could occur in ponds but repopulation should be rapid. Maximum residues in fish and crayfish tissue in such ponds would not exceed those predicted for CIC. These are 0.26 ppm, 0.002 ppm, and 6.5 ppm for methyl parathion, methomyl, and permethrin.

As predicted in the CIC evaluation, there is no indication that the use of insecticides under the OPM program would have a negative effect on the fish farms and hatcheries in the Red river basin.

Boll Weevil Eradication:

Santee River Basin. Table 45 summarizes the maximum residues of diflubenzuron, malathion, and azinphos-methyl expected to occur in the Santee river basin, as predicted in the T&D module, under the BWE program.

TABLE 45

MAXIMUM RESIDUES (COUPLED[a]) EXPECTED UNDER THE BWE PROGRAM IN THE SANTEE RIVER BASIN (mg/liter)

Segment	Diflubenzuron	Malathion	Azinphos-methyl
Catawba	<0.0001	0.000457	<0.0001
Saluda	<0.0001	0.000191	<0.0001
Broad	<0.0001	0.000279	<0.0001

[a] "Coupled" is defined as that pesticide borne by suspended sediment particles and that released into solution.

The maximum residues expected to exist in the Santee River under the BWE program are very low. Concentrations of both diflubenzuron and azinphos-methyl are not expected to exceed 0.1 ppb and the maximum concentration of malathion is less than 0.5 ppb. At these concentrations, neither diflubenzuron nor azinphos-methyl, both of which are fairly short-lived, should pose any threat to aquatic organisms. The predicted concentrations of malathion may affect the most sensitive aquatic insects under extreme conditions, but these instances should be mild and followed by rapid repopulation of affected waters.

The maximum residues expected to reach ponds with characteristics similar to those described in the T&D module are listed below:

- diflubenzuron 0.038 mg/liter
- malathion 0.26 mg/liter
- azinphos-methyl 0.058 mg/liter

These residues, expected to occur in ponds under worst-case calculations, are higher than those expected to exist in the Santee River.

The predicted concentration of diflubenzuron is less than that shown to cause mortality to fish under laboratory conditions, but greater than that shown to be toxic to sensitive aquatic insects and crustacea. Consequently, under extreme conditions, these concentrations could decrease populations of some aquatic insects and juvenile crustacea. However, diflubenzuron is very short-lived in natural waters, so these effects are expected to be insignificant and not widespread.

Predicted concentrations of malathion are slightly less than those shown to cause mortality in sensitive fish species such as the bluegill. Under extreme conditions, some fish kills could occur in ponds receiving runoff from fields

recently treated with malathion. Under the assumed conditions, declines in populations of some aquatic insects could result. Given the short half-life of malathion in water, this mortality should not be total, and recovery of these insect populations should be fairly rapid.

Less is known about the toxicity of azinphos-methyl than of diflubenzuron and malathion, but it appears to be very toxic to fish in laboratory tests. Predicted concentrations in the farm ponds described in the T&D scenario are greater than those shown to be toxic to several members of the cyprinidae and centrarchidae, two families of fish commonly represented in farm ponds. Should these predicted concentrations be reached, some mortality of fish, insects, and crustacea are likely. More tolerant fish species should not be affected.

As described in Appendix A, KFR 302-81 (Attachment H), neither malathion or azinphos-methyl are expected to accumulate in fish tissue, while diflubenzuron may concentrate to levels 50 times those found in the water. The highest residues likely to occur in fish or crayfish tissue under the BWE strategy would occur in the farm ponds. These residues are not expected to exceed 1.9 ppm, 0.26 ppm, and 0.058 ppm for diflubenzuron, malathion, and azinphos-methyl.

The fact that the CIC program had no identifiable impacts on the fish farms and hatcheries in the Santee river basin indicates a low probability of these facilities receiving pesticide contaminated runoff from cottonfields. Consequently, no adverse impacts are expected for these facilities under a BWE program.

Flint River Basin. There were no insecticide residues greater than 0.0001 mg/liter predicted for the waters of the Flint River under the BWE program.

The residues predicted for the water of the Flint River are lower than those shown to be toxic to aquatic organisms in laboratory tests. Consequently, no impacts to the aquatic organisms of the Flint River are expected under the BWE program.

Insecticide use under the BWE program is much the same in all three river basins, so the conditions and impacts described for the farm ponds in the T&D module are likely to be encountered in each river basin. As described for the Santee, these impacts include limited mortality of sensitive fish species, juvenile crustacea, and aquatic insects. Tissue residues likely to be encountered in fish and crayfish taken from these ponds should not exceed 1.9 ppm, 0.26 ppm, and 0.058 ppm for diflubenzuron, malathion, and azinphos-methyl.

Red River Basin. Table 46 summarizes the maximum residues of diflubenzuron, malathion, and azinphos-methyl expected to occur in the Red River, as predicted in the T&D module, under the BWE program.

TABLE 46

MAXIMUM RESIDUES (COUPLED[a]) EXPECTED UNDER THE BWE PROGRAM IN THE RED RIVER BASIN (mg/liter)

Segment	Diflubenzuron	Malathion	Azinphos-methyl
1 and 3	<0.0001	0.0021	0.0006
5	0.0062	0.1140	0.0319
9	0.0052	0.0795	0.0200
11	0.0010	0.0146	0.0035
13	0.0047	0.0650	0.0159
15	0.0017	0.0218	0.0057
16	0.0007	0.0108	0.0026
17	0.0011	0.0161	0.0052
23	0.0018	0.0271	0.0074
27	<0.0001	<0.0001	<0.0001

[a] "Coupled" is defined as that pesticide borne by suspended sediment particles and that released into solution.

Residues predicted for the Red River were slightly higher for all three insecticides. Should predicted concentrations be reached, some mortality of fish, crustacea, and insects could be expected under extreme conditions. These insecticides are relatively short-lived and effects are not expected to persist.

The impacts to farm ponds in the Red river basin with conditions similar to those described in the T&D module include limited mortality of sensitive fish species, juvenile crustacea, and aquatic insects. These are already described for the Santee river basin. As the insecticide use under the BWE program is the same in each basin, these impacts can be expected to occur in vulnerable standing-water habitats in the Red river basin. Tissue residues in fish and crayfish would be higher in samples from the ponds than from organisms taken in the Red River. As described earlier, these are not expected to exceed 1.9 ppm, 0.26 ppm, and 0.058 ppm for diflubenzuron, malathion, and azinphos-methyl. As in the Santee and Flint river basins, no significant impacts are expected for the fish farms and hatcheries under the BWE program.

WILDLIFE

The Wildlife module evaluates the effects of boll weevil control program insecticides on terrestrial vertebrates by estimating vertebrate exposure to insecticides at program application levels and comparing those estimates with laboratory toxicity information on the same or related species. Weight, dietary composition, daily food intake, and body surface area of each representative cottonfield wildlife species are listed in Table 47. Immediate direct effects are evaluated by comparison with acute toxicity studies. Chronic toxicity and bioaccumulation effects are based on available studies of

TABLE 47

REPRESENTATIVE WILDLIFE SPECIES WITH ASSOCIATED BIOLOGICAL PARAMETERS

Species	Weight (g)	Daily Food Intake (g)	Diet Composition	Body Surface Area (CM^2)	Vegetation Contact Factor ($mg^{-.25}$)	Inhalation Volume (ml/sec)
Redwing Blackbird	45	9	Insects & seeds	127	0.386	0.433
Meadowlark	65	11	Insects	162	0.352	0.583
Bobwhite Quail	170	15	Insects & seeds	307	0.277	1.217
Mourning Dove	100	11.2	Seeds	216	0.316	0.80
Painted Bunting	24	8	Insects esp. boll-worms & boll weevils	83	0.452	0.267
Cottontail Rabbit	1350	53	Ground vegetation	1224	0.165	14.033
Cotton Rat	157	39	Ground vegetation	292	0.283	1.433
Whitetail Deer	68,040	2450	Browse & forbs	16728	0.062	184.78
Six-lined Racerunner	18	4	Insects	69	0.485	0.108
Hognose Snake	40	22	Toads	117	0.398	0.20
Fowler's Toad	22	5	Insects	79	0.462	0.125
Belted Kingfisher	250	20	Small fish	398		

long-term effects and input and degradation rates of boll weevil insecticides used in each program. The toxicity and environmental fate of these insecticides can be found in Appendix A, KFR 302-81 (Attachment H).

Because the boll weevil insecticides are so short-lived (half-lives of less than a week), are readily metabolized by vertebrate species, and are not lipophilic, as the organochlorides are, neither chronic effects nor bioaccumulation are anticipated. Permethrin and diflubenzuron, with half-lives of 4 and 3 weeks respectively, are the exceptions in terms of relative environmental persistence. During the spray program, these two pesticides could tend to accumulate on foliage and in the soil to some extent. However, since neither pesticide is toxic to terrestrial vertebrates at anticipated program use levels, no long-term effects are expected.

Current Insect Control:

Table 48 lists the pesticides used in the current insect control program, with application rates and intervals. Aerial concentrations and foliar residue levels are included.

Estimated doses of each CIC program pesticide via inhalation, dermal, and ingestion exposure are listed in Table 49 for each representative species. Abbreviations used in the tables are: (1) redwing blackbird (RWB), (2) meadowlark (MDL), (3) bobwhite quail (BWQ), (4) mourning dove (MND), (5) painted bunting (PBT), (6) cottontail rabbit (CRB), (7) cotton rat (CNR), (8) white-tailed deer (WTD), (9) six-lined racerunner (SLR), (1) hognose snake (HNS), (11) fowler's toad (FLT), (12) belted kingfisher (BKF). See Appendix B, of KFR 302-81, (Attachment H) for scientific names.

The estimated maximum exposures would be expected to produce some mortality in representative species, in particularly small mammals and birds. Nevertheless,

TABLE 48

CIC PROGRAM - ESTIMATED PESTICIDE RESIDUE CONCENTRATIONS

Chemical	Appl. Rate (lb. a.i./acre)	Appl. Intervals (Days)	At Highest Concentration (mg/30 acres)	Total Surface Area (mg/m^2)	Cotton Leaf Wet Weight (mg/kg)
Methyl Parathion	0.684	6	9.3079×10^6	22.549	208.87
Methomyl	0.500	25	6.804×10^6	16.843	152.68
Permethrin	0.111	6	1.5105×10^6	3.659	33.89

TABLE 49

CIC PROGRAM - REPRESENTATIVE SPECIES EXPOSURES (mg)

Species	Inhalation	Dermal	Ingestion	Total (mg/kg body wt.)
		Methyl Parathion		
RWB	5.45×10^{-5}	0.396	1.27	36.98
MDL	7.33×10^{-5}	0.493	2.48	45.74
BWQ	1.58×10^{-4}	0.884	2.48	45.74
MND	1.01×10^{-4}	0.641	0.63	17.61
PBT	3.36×10^{-5}	0.272	1.80	86.33
CRB	1.76×10^{-3}	3.220	11.07	10.59
CNR	1.80×10^{-4}	0.844	8.15	57.29
WTD	2.32×10^{-2}	40.060	511.73	8.11
SLR	1.36×10^{-5}	0.232	0.90	63.00
HNS	2.52×10^{-5}	0.369	1.39	43.98
FLT	1.57×10^{-5}	0.260	1.13	63.18
BKF	--	--	0.01	0.02
		Methomyl		
RWB	3.98×10^{-5}	0.290	0.93	27.04
MDL	5.36×10^{-5}	0.361	1.81	33.40
BWQ	1.12×10^{-4}	0.646	1.55	12.92
MND	7.35×10^{-5}	0.468	0.46	9.30
PBT	2.45×10^{-5}	0.199	1.32	63.29
CRB	1.29×10^{-3}	2.351	8.09	7.73
CNR	1.32×10^{-4}	0.617	5.95	41.83
WTD	1.70×10^{-2}	29.280	374.07	5.93
SLR	0.99×10^{-5}	0.169	0.66	45.94
HNS	1.84×10^{-5}	0.269	1.01	31.85
FLT	1.15×10^{-5}	0.182	0.82	45.68
BKF	--	--	4×10^{-6}	1.6×10^{-5}
		Permethrin		
RWB	1.06×10^{-5}	0.064	0.21	6.00
MDL	1.19×10^{-5}	0.080	0.40	7.43
BWQ	2.48×10^{-5}	0.143	0.34	2.86
MND	1.63×10^{-5}	0.104	0.10	2.06
PBT	5.45×10^{-6}	0.044	0.29	14.04
CRB	2.86×10^{-4}	0.522	1.80	1.72
CNR	2.93×10^{-5}	0.137	1.32	9.28
WTD	3.77×10^{-3}	6.500	83.03	1.32
SLR	2.21×10^{-6}	0.037	0.15	10.22
HNS	4.08×10^{-6}	0.060	0.22	7.10
FLT	2.55×10^{-6}	0.041	0.18	10.18
BKF	--	--	0.14	0.56

it must be emphasized that for many reasons the likelihood of heavy mortality occurring is small. First, in terms of dermal exposure, most species, especially birds, are mobile enough to avoid direct spray, particularly in light of the disturbance that spray equipment makes, and the instinctive avoidance behavior of vertebrates. The same is also the case for inhalation exposure. Only those individuals remaining downwind from spray vehicles are likely to inhale pesticides but again are likely to receive less than the maximum level due to instinctive avoidance behavior.

The highest anticipated exposure is from ingestion of plants, insects, and seeds. Herbivores, such as the cottontail rabbit and white-tailed deer have been noted[36/] to use cotton as food only incidently, so cotton plants may form only a small fraction of their diets. The more realistic effect on terrestrial herbivores is likely to occur when they ingest vegetation (forbs, grasses, and browse) on the periphery of the cottonfields that could be contaminated via spray drift. Drift residue levels, however, are only a fraction of cottonfield residue levels.

Insectivores and granivores, which ingest arthropods or seeds in cottonfields, may be expected to ingest the highest levels of pesticide. However, their continuous movement in feeding, in most cases, makes ingestion of total daily intake in a particular cottonfield immediately after treatment highly unlikely.

The immediacy of ingestion for maximum exposure is a necessary consideration because of the rapidity with which CIC program insecticides degrade. Residue concentrations within a few hours post-treatment are, in each case, much reduced from initial maximum levels.

The foregoing considerations must be dealt with in assessing the likely real impact on terrestrial vertebrates of CIC insecticides, and it is apparent from these that acute toxic effects are unlikely to occur. In general, terrestrial wildlife would not be expected to be affected by the CIC program.

Optimum Pest Management:

Table 50 lists OPM program pesticide application rates and calculated residue levels in a 30-acre cottonfield. Table 51 lists inhalation, dermal, and ingestion exposure (milligrams) and total exposure (mg/kg body weight) for 12 representative species under the OPM program.

Total methyl parathion exposure is slightly lower than, permethrin exposure slightly higher than, and methomyl exposure the same as, the CIC insecticide program exposure levels. The same conclusions concerning acute toxicity under maximum possible exposure may be reached here, i.e., there will be some mortality among smaller species of mammals, birds, reptiles, and amphibians. However, the same considerations in terms of mobility and avoidance behavior is the case under the OPM program. Therefore, it is unlikely that any wildlife species will be affected by the OPM program, although mortality may occur in a few isolated individuals.

Boll Weevil Eradication:

Table 52 lists BWE insecticide application rates and calculated residue levels in a 30-acre cottonfield. Table 53 lists the estimated maximum representative species exposure levels to the three BWE program insecticides.

In only a single species, the painted bunting, was maximum exposure level (126 ppm) to malathion near the LD_{50} level (150-200 ppm) for a vertebrate species.

TABLE 50

OPM PROGRAM - ESTIMATED PESTICIDE RESIDUE CONCENTRATIONS

Chemical	Appl. Rate (lb. a.i./acre)	Appl. Intervals (Days)	At Highest Concentration (mg/30 acres)	Total Surface Area (mg/m^2)	Cotton Leaf Wet Weight (mg/kg)
Methyl Parathion	0.650	10	$8.8452X10^6$	21.428	198.49
Methomyl	0.500	25	$6.804X10^6$	16.843	152.68
Permethrin	0.113	6	$1.8099X10^6$	4.385	40.61

TABLE 51

OPM PROGRAM - REPRESENTATIVE SPECIES EXPOSURES (mg)

Species	Inhalation	Dermal	Ingestion	Total (mg/kg body wt.)
		Methyl Parathion		
RWB	5.18×10^{-5}	0.377	1.21	35.16
MDL	6.97×10^{-5}	0.469	2.36	43.52
BWQ	1.45×10^{-4}	0.840	2.01	16.76
MND	9.56×10^{-5}	0.609	0.60	12.09
PBT	3.19×10^{-5}	0.258	1.71	82.00
CNR	1.71×10^{-4}	0.803	7.74	54.51
WTD	2.21×10^{-2}	38.070	486.30	7.71
SLR	1.29×10^{-2}	0.220	0.86	59.89
HNS	2.31×10^{-5}	0.521	1.32	45.95
FLT	1.49×10^{-5}	0.247	1.07	59.86
BKF	—	--	0.01	0.02
		Methomyl		
RWB	3.98×10^{-5}	0.290	0.93	27.04
MDL	5.36×10^{-5}	0.361	1.81	33.40
BWQ	1.12×10^{-4}	0.646	1.55	12.92
MND	7.35×10^{-5}	0.468	0.46	9.30
PBT	2.45×10^{-5}	0.199	1.32	63.29
CRB	1.29×10^{-3}	2.351	8.09	7.73
CNR	1.32×10^{-4}	0.617	5.95	41.83
WTD	1.70×10^{-2}	29.280	374.07	5.93
SLR	0.99×10^{-5}	0.169	0.66	45.94
HNS	1.84×10^{-5}	0.269	1.01	31.85
FLT	1.15×10^{-5}	0.182	0.82	45.68
BKF	--	--	4×10^{-6}	1.6×10^{-5}
		Permethrin		
RWB	0.88×10^{-5}	0.078	0.25	7.22
MDL	1.42×10^{-5}	0.096	0.48	8.89
BWQ	2.98×10^{-5}	0.172	0.41	3.43
MND	1.96×10^{-5}	0.125	0.12	2.48
PBT	6.53×10^{-6}	0.052	0.35	16.79
CRB	3.43×10^{-4}	0.626	2.15	2.06
CNR	3.50×10^{-5}	0.164	1.58	11.11
WTD	4.52×10^{-3}	7.790	99.49	1.58
SLR	2.65×10^{-6}	0.045	0.18	12.22
HNS	4.89×10^{-6}	0.071	0.27	8.53
FLT	3.06×10^{-6}	0.051	0.22	12.22
BKF	--	--	0.14	0.56

TABLE 52

BWE PROGRAM - ESTIMATED PESTICIDE RESIDUE CONCENTRATIONS

Chemical	Appl. Rate (lb. a.i./acre)	Appl. Intervals (Days)	At Highest Concentration (mg/30 acres)	Total Surface Area (mg/m^2)	Cotton Leaf Wet Weight (mg/kg)
Malathion	1.00	10.5	13.608×10^6	32.980	305.36
Diflubenzuron	0.06	7	0.8165×10^6	1.978	18.32
Azinphos-methyl	0.25	--	3.402×10^6	8.242	76.34

TABLE 53

BWE PROGRAM - REPRESENTATIVE SPECIES EXPOSURES (mg)

Species	Inhalation	Dermal	Ingestion	Total (mg/kg body wt.)
Malathion				
RWB	7.96×10^{-5}	0.581	1.85	54.02
MDL	1.07×10^{-4}	0.722	3.63	66.95
BWQ	2.24×10^{-4}	1.292	3.09	25.78
MND	1.47×10^{-4}	0.937	0.92	18.60
PBT	4.91×10^{-5}	0.398	2.64	126.58
CRB	2.58×10^{-3}	4.701	16.18	15.46
CNR	2.63×10^{-4}	1.235	11.91	83.73
WTD	3.40×10^{-2}	58.570	748.13	11.86
SLR	1.99×10^{-5}	0.337	1.32	92.06
HNS	3.68×10^{-5}	0.540	2.03	64.25
FLT	2.30×10^{-5}	0.380	1.65	92.27
BKF	--	--	1.2×10^{-3}	4.8×10^{-3}
Diflubenzuron				
RWB	4.78×10^{-5}	0.035	0.111	3.24
MDl	6.43×10^{-6}	0.043	0.217	4.00
BWQ	1.34×10^{-5}	0.078	0.185	1.55
MND	0.88×10^{-5}	0.057	0.055	1.12
PBT	2.94×10^{-6}	0.023	0.158	7.54
CRB	1.54×10^{-4}	0.282	0.971	0.93
CNR	1.58×10^{-5}	0.074	0.714	5.02
WTD	2.03×10^{-3}	3.514	44.884	0.71
SLR	1.19×10^{-6}	0.021	0.079	5.56
HNS	2.20×10^{-6}	0.032	0.122	3.85
FLT	1.38×10^{-6}	0.023	0.099	5.55
BKF	--	--	0.040	0.16
Azinphos-methyl				
RWB	1.99×10^{-5}	0.146	0.464	13.57
MDL	2.67×10^{-5}	0.181	0.908	16.75
BWQ	5.58×10^{-5}	0.323	0.773	6.45
MND	3.68×10^{-5}	0.234	0.231	4.65
PBT	1.22×10^{-5}	0.099	0.660	31.63
CRB	6.45×10^{-4}	1.175	4.050	3.87
CNR	6.59×10^{-5}	0.309	2.980	20.95
WTD	8.49×10^{-3}	14.640	187.030	2.96
SLR	4.98×10^{-6}	0.085	0.330	23.06
HNS	9.19×10^{-6}	0.134	0.508	16.05
FLT	5.75×10^{-6}	0.095	0.413	23.09
BKF	--	--	0.006	0.02

Although malathion's 3-day half-life and its rapid metabolism by terrestrial vertebrates lead to the conclusion that acute, chronic, or accumulative effects will not generally occur, mortality of single individuals, in rare cases, may occur.

Diflubenzuron toxicities to vertebrates are several thousand parts per million, while estimated maximum exposures are less than 10 ppm. Therefore, no toxic effects are anticipated due to diflubenzuron application from the BWE program.

Estimated azinphos-methyl maximum exposure levels indicate that in the case of small mammals, some mortality may occur. Total intake in the cotton rat is almost twice the oral LD_{50} value (11-13 mg/kg) for laboratory rats. Avian species, to which azinphos-methyl is much less toxic, should experience little or no mortality.

ENDANGERED AND THREATENED SPECIES

The Endangered and Threatened (E&T) Species module draws from the results of the Wildlife module and Aquatics module to determine to what extent E&T Species may be affected by boll weevil control programs. This is done in compliance with regulations for the Endangered Species Act of 1973.

Results of the E&T Species module provide program managers with the potential impact of the program on E&T species and their habitats. Fundamental to the purpose of this module is the principal that no E&T species is likely to be jeopardized by the programs. In the case of liklihood of jeopardization, program managers will mitigate the circumstances of the likelihood of impact.

The initial report on the environmental evaluation of the beltwide programs (KFR 279-80, Attachment F) provided first phase data on endangered and threatened species. The current results include updated information on

Federally listed E&T species that occur in the Santee, Flint, and Red river basins as well as listing those species occurring in the three river basins that are included on the corresponding State's list of endangered, threatened, rare or unusual species. Table 54 lists the E&T species in the Santee, Flint, and Red river basins, their Federal or State status, and a brief description of their distribution. All E&T species occurring in the Cotton Belt are discussed in Attachment M.

Current Insect Control:

In the Santee river basin the cooper's hawk, a bird of open woodlands and wood margins, may be exposed if it ingests its prey of small birds and mammals immediately after they have become exposed to residues. Even in this unlikely event, the low avian toxicities of the CIC insecticides ensures quick metabolism and no acute effects.

The osprey may receive insecticide residues by ingesting exposed fish. As was the case with the belted kingfisher in the Wildlife module, no adverse effects are anticipated.

The wood stork, which summers in coastal swamps and marshes, will not be affected by the CIC spray program.

The Carolina darter may possibly ingest some insecticide through its aquatic food chain. When anticipated residue levels in the aquatic system are considered, however, it is unlikely this species will be affected.

The State listed threatened beetle species (*Myotrupes retuses*) may possibly be affected by the program insecticides. Its distribution and status relative to potential treatment areas should be determined and mapped so that program managers may ensure that spray drift does not affect this species. It occurs

TABLE 54

ENDANGERED AND THREATENED SPECIES OF
GEORGIA, SOUTH CAROLINA, AND LOUISIANA

Flint River Basin (Georgia)

Species	Status[a]	Distribution[b]
Indiana Bat	FE	Record for Walker County
Red-cockaded Woodpecker	FE	Statewide
Peregrine Falcon	FE	Records for Walker, Murray, Spaulding, Walton, Fulton, Quitman, Irwin, Camden, McIntosh, and Bryan Counties
Southern Bald Eagle	FE	Statewide
American Alligator	FT coastal areas FE inland	Present in 90 counties in central and south Georgia.

Red River Basin (Louisiana)

Cougar	FE	Known or likely to occur in northeast Louisiana, in Caddo Clunty, in the Red River Valley, and St. Tammany County.
Peregrine Falcon	FE	Louisiana is included in the main migration route
Ivory-billed Woodpecker	FE	Past records for Morehouse, West Carroll East, Carroll, Madison, Franklin, Tensas, Concordia, West Feliciana, Iberville, Iberia, and Lafourch Parishes.

TABLE 54
(Continued)

Red River Basin (Louisiana)		
Species	Status	Distribution
Red-cockaded Woodpecker	FE	Records prior to 1960 for Morehouse, Ouachita, Caldwell, Clairborne, and Bienville Counties.
American Alligator	FE inland FT coastal areas	Found in river systems and swamps throughout Louisiana, greatest concentration occurs in the coastal marshes.

Santee River Basin (South Carolina)		
Cougar	FE	Reports of sightings are Statewide.
Indiana Bat	FE	May be found in caves in the mountainous regions of South Carolina.
Bald Eagle	FE	Found predominately in the lower coastal plain, also inland along rivers and lakes; nesting territory in Kershaw, Georgetown, Charleston, Colleton, Beaufort, and Jasper Counties.
Red-cockaded Woodpecker	FE	Records for Aiken, Barnwell, Beaufort, Berkeley, Calhoun, Charleston, Chesterfield, Clarendon, Colleton, Darlington, Dillon, Dorchester, Edgefield, Florence, Georgetown, Hampton, Horry, Laurens, Lee, Lexington, Orangeburg, Richland, Sumter, and Williamburg Counties; Francis Marion National Forest.

TABLE 54
(Continued)

Santee River Basin (South Carolina)

Species	Status	Distribution
Kirtland's Warbler	FE	Rare transient over most of the State; recorded north to Chester Counties, east to Charleston, south to Beaufort.
Golden Eagle	SE	Migrating and wintering populations found in the State; may spend considerable time feeding in the mountainous regions.
Coal Skink	SE	Single population in Pickens County.
Carolina Darter	ST	Found in the streams in the sandhills, Sandhills National Wildlife Refuge; Santee River drainage, inhabits small to medium tributaries to the Catawba River (York and Lancaster Counties).
Zig Zag Salamander	SE	Rare in Steven's Creek Natural Area and Steven's Creek drainage (McCormick County); other populations occur in suitable habitats in the Piedmont and Blue Ridge Provinces of the State.
Coleoptera (Beetle) Myotrupes retuses	ST	Inhabits the sandy soils of former Pleistocene islands Found in Columbia, near Lexington, Blaney (Kershaw County), and Windsor (Aiken County).

TABLE 54
(Continued)

Santee River Basin (South Carolina)

Species	Status	Distribution
Swallow-tailed Kite	SE	Nesting sites in the Francis Marion Forest, formerly over most of the State, now chiefly in the swampy areas of the eastern section; recorded north to Cherokee and Chester Counties, east to Georgetown and Charleston Counties, south to Beaufort County, west to Aiken and Pickens County.
Coopers Hawk	ST	Permanent resident throughout the state; observed in Cherokee, Lancaster, and Darlington Counties; east to Horry County, south to Beaufort, west to Oconee and Pickens.
Wood Stork	ST	Does not breed in South Carolina, summers in marsh and swamp on the coast; known north to Lancaster County, east to Georgetown County and Charleston, south to Beaufort County, and west to Aiken and Lexington Counties; may be nesting at Myrant's Reserve at Fairlawn Plantation.
American Osprey	ST	Rare in winter, but breeds here in summer; coastal bird.

[a] FE = Federal endangered SE = State Endangered
FT = Federal threatened ST = State threatened

[b] Distribution information in no respect constitutes a description of "critical habitat" as defined under the Endangered Species Act of 1973 and compiled by the Office of Endangered Species, U.S. Department of the Interior.

in the extreme southeastern portion of the Santee river basin so that only that particular area need be considered in ascertaining its proximity to cottonfields to be treated.

None of the Flint river basin E&T species are associated with cottonfields and the habitats they are likely to frequent are not in close proximity to cottonfields. Possible effects of CIC program insecticides consist of the extremely unlikely occurrence of the red-cockaded woodpecker feeding on insects in or near a cottonfield or a bald eagle or alligator ingesting fish with significant insecticide residues.

The extremely low probability of these events occurring, coupled with the low vertebrate toxicities of CIC insecticides and low anticipated residue levels, lead to the conclusion that no Flint river basin E&T species will be affected by the program.

The cougar and ivory-billed woodpecker are additional species to be considered in the Red river basin. The cougar feeds primarily on deer; the ivory-billed on bark grubs. The habitat niches of both species include large tracts of undisturbed land. In the case of the ivory-billed woodpecker, old growth bottomland forest is preferred.

It is extremely unlikely that the CIC program will affect either of these species in view of their ecological niches. There is some indication that the ivory-billed woodpecker already may be extinct. In the case of the cougar, residues may possibly be ingested in a deer kill. However, low mammalian toxicities, low application rates, and high degradation rates of the CIC insecticides ensure no effect on cougars even in the unlikely event of ingestion of an exposed deer.

Optimum Pest Management:

The OPM program evaluation involves the same insecticides (methyl parathion, methomyl, and permethrin) used in the CIC program; therefore, the same conclusions regarding possible effects on E&T species also apply to this program. In particular, the State-listed threatened beetle species of the Santee River basin could be affected by the OPM insecticides. Therefore, its distribution in relation to treatment areas should be ascertained before treatments are made in that portion of the Santee.

Boll Weevil Eradication:

Since none of the insecticides (malathion, diflubenzuron, and azinphos-methyl) are persistent or lipophilic, as the organochloride pesticides are, no food chain effects are anticipated.

Only acute toxic effects are in need of consideration here and it is unlikely, given the application rates and expected maximum concentrations, that any E&T species will be adversely affected. As in the CIC and OPM programs, the Santee's State threatened beetle species must be considered in the BWE program to determine its habitat relative to the treatment area.

Where a spray program has some likelihood of impacting an E&T's feeding area (if that particular area can be identified) steps should be taken to ensure that those indirect effects can be avoided.

HUMAN INGESTION

The purpose of the Human Ingestion module is to estimate the extent to which humans may be indirectly exposed to program insecticides through their local diet. It is assumed that local residents will have at least part of their diet supplied from local sources, and therefore, that their diet will potentially be

more affected by a program in their locality than persons outside that locality. Thus, the resident person whose diet is considered in the analysis in this module is assumed to live in the region being examined.

Animal feeding studies indicate that, because of the nonpersistence ot the insecticides used in these programs, large mammals are relatively unaffected by oral ingestion of program insecticides and tend to eliminate them rapidly from their bodies. Little, if any, of the insecticides get into the muscle or adipose tissue. Therefore, it was believed, before the analysis was undertaken, that these programs probably would not expose humans to significant amounts of insecticide through their diets. The analysis corroborates this belief.

The analysis presented is a form of worst-case analysis. A number of simplifying assumptions are made which result in an overestimation of the amount of insecticide ingested and ensures that the analysis produces upper bounds for daily intake.

The information on residues that was utilized in the meat residue calculation tables was obtained from tables of other modules. Thus, residue values for beef, pork, and poultry came from tables in the Nontarget Agriculture module, whereas residue values for fish came from the Aquatics module and residues for wildlife came from the Wildlife module.

Theoretically, there should be a separate meat residue calculation table for each of the insecticides used within the river basins. However, to make the display of results more compact, all meat residue calculations were combined in the tables that follow.

For "Beef, Pork," the beef residue was used because no pork value was calculated. Beef cattle, because they are more likely to graze near (or even in) cottonfields, are expected to be more exposed to the insecticides than swine.

Therefore, beef residues resulting from a program would probably be at least equal to or greater than pork residues. Thus, the use of beef residues was in concert with the worst-case analyses. Chicken residues were used for poultry since little data were available to support residue calculations for turkeys or ducks. For fish, upper bounds were given that represent all fish, but for wildlife there was a choice among doves, quail, rabbit, and deer. The wildlife residue value used for a given insecticide/program combination was that which was highest among the four for that insecticide/program combination. (In all cases this was the residue estimate for quail). Values in the table in the residue column reflect that the estimated level was less than 10 parts per billion. These are not reported because their contribution to R_T is insignificant.

The final human ingestion calculations utilize information about residues in other food categories. This residue information appears in other tables in the Nontarget Agriculture module. The food item with the highest estimated residue level was used as the representative for that category. For milk products, a value equal to 10 percent of the maximum dairy cow ingestion figure was used, while for eggs, a value equal to 10 percent of the maximum expected ingestion for chickens was used. The residue for sugar was that on sugarcane.

Current Insect Control:

Tables 55 and 56 provide the meat residue and human ingestion calculations for the CIC program in the Santee river basin.

For the Flint river basin, the meat residue and human ingestion calcuations are the same as for the Santee. Similarly, the CIC meat residue and human ingestion calcualtions for the Red river basin are essentially the same as for the Santee river basin.

TABLE 55

MEAT RESIDUE CALCULATIONS
SANTEE RIVER BASIN--CIC PROGRAM

Source	p	Methyl Para. r[a]	Methyl Para. p x r	Methomyl r	Methomyl p x r	Permethrin r	Permethrin p x r
Beef, Pork	0.63	0	0	0	0	0	0
Poultry	0.26	0	0	0	0	0	0
Fish	0.08	0.26	0.021	0.002	0	6.5	0.520
Wildlife	0.03	4.4	0.132	3.2	0.096	0.71	0.021
R =			0.153		0.096		0.541

[a] includes an elimination factor of 0.25 for beef, pork, poultry, and wildlife.

TABLE 56

HUMAN INGESTION CALCULATIONS
SANTEE RIVER BASIN--CIC PROGRAM

Source	P	Methyl Para. R	Methyl Para. P X R	Methomyl R	Methomyl P X R	Permethrin R	Permethrin P X R
Meat	0.010	0.153	0.0015	0.096	0.001	0.541	0.0054
Grain	0.014	0	0	0	0	0	0
Milk Prod.	0.001	0	0	0	0	0	0
Eggs	0.0015	0	0	0	0	0	0
Fruits	0.0055	0.101	0	0	0	0.030	0
Sugar	0.0015	0	0	0	0	0	0
R_T's =			0.0015		0.001		0.0054

The maximum human ingestion daily intake expected under the CIC program in any of the three river basins is 0.005 ppm of permethrin. Both methyl parathion and methomyl intakes would be less than 0.002 ppm. These numbers are solely due to estimated upperbound residues in fish and wildlife--estimates which assume very worst-case scenarios.

The analysis suggests that humans are not dangerously exposed to the CIC program insecticides considered.

Optimum Pest Management:

Tables 57 and 58 provide information relative to meat residue calculations and human ingestion calculations for the OPM program in the Santee river basin.

TABLE 57

MEAT RESIDUE CALCULATIONS
SANTEE RIVER BASIN--OPM PROGRAM

		Methyl Para.		Methomyl		Permethrin	
Source	p	r	p x r	r	p x r	r	p x r
Beef, Pork	0.63	0	0	0	0	0	0
Poultry	0.26	0	0	0	0	0	0
Fish	0.08	0.26	0.021	0.020	0.002	6.5	0.520
Wildlife	0.03	4.19	0.126	0.322	0.097	0.86	0.025
	R =		0.147		0.099		0.545

TABLE 58

HUMAN INGESTION CALCULATIONS
SANTEE RIVER BASIN--OPM PROGRAM

Source	P	Methyl Para. R	Methyl Para. P X R	Methomyl R	Methomyl P X R	Permethrin R	Permethrin P X R
Meat	0.010	0.147	0.0015	0.099	0.001	0.545	0.0055
Grain	0.014	0	0	0	0	0	0
Milk Prod.	0.001	0	0	0	0	0	0
Eggs	0.0015	0	0	0	0	0	0
Fruits	0.0055	0	0	0	0	0	0
Sugar	0.0015	0	0	0	0	0	0
R_T's =			0.0015		0.001		0.0055

The meat residue calculations and human ingestion calculations for the Flint river basin are the same as those for the Santee. Similarly, the OPM meat residue calculation and human ingestion calculations for the Red river basin are essentially the same as those for the Santee river basin.

There is no evidence that the OPM program will introduce significant levels of insecticide into the human diet. The highest estimated residue level introduced is 0.006 ppm of permethrin, and that figure is almost totally due to worst-case estimates of levels of permethrin in fish.

Boll Weevil Eradication:

Tables 59 and 60 present the meat residues and human ingestion calcualtions for the BWE program in the Santee river basin.

TABLE 59

MEAT RESIDUE CALCULATIONS
SANTEE RIVER BASIN--BWE PROGRAM

		Diflubenzuron		Malathion		Azinphos-methyl	
Source	p	r	p x r	r	p x r	r	p x r
Beef, Pork	0.63	0	0	0	0	0	0
Poultry	0.26	0	0	0	0	0	0
Fish	0.08	1.9	0.152	0.26	0.021	0.058	0.005
Wildlife	0.03	0.39	0.011	6.45	0.193	1.61	0.048
R =			0.163		0.214		0.053

TABLE 60

HUMAN INGESTION CALCULATIONS
SANTEE RIVER BASIN--BWE PROGRAM

		Diflubenzuron		Malathion		Azinphos-methyl	
Source	P	R	P X R	R	P X R	R	P X R
Meat	0.010	0.163	0.0016	0.214	0.0021	0.053	0.0005
Grain	0.014	0	0	0.024	0	0	0
Milk Prod.	0.001	0	0	0	0	0	0
Eggs	0.0015	0	0	0	0	0	0
Fruits	0.0055	0	0	0	0	0	0
Sugar	0.0015	0	0	0	0	0	0
R_T's =			0.0016		0.0021		0.0005

The BWE meat residue calculation and human ingestion calculations for the Flint and Red river basins are essentially the same as those for the Santee river basin.

There is no evidence that the BWE program will introduce significant levels of insecticide into the human diet. The highest estimated BWE residue level

introduced is 0.002 ppm of malathion, and that figure is almost totally due to worst-case estimates of levels of malathion in quail.

Because the insecticide levels derived were small and considerably less than the acceptable daily intakes (ADI's) for those insecticides for which ADI's have been established, none of the programs should pose a human ingestion risk.

RESEARCH PROGRAM CONFLICTS

The objective of the Research Program Conflicts module was to evaluate, and to the extent possible, quantify the effect of a beltwide program upon ongoing research being conducted in and around the potential program areas.

This analysis was a predictive assessment of impact in that the beltwide programs under study have not yet been implemented on the river basins evaluated. It was, therefore, necessary to conduct a more general analysis of the type of research which may be affected should a particular program be implemented. The extent of damage or impact, however, was impossible to quantify in the absence of actual program implementation.

It was determined by an analysis of the nature of each beltwide program that only the BWE quarantine activites may be expected to result in conflicts with ongoing research.

In order to determine whether or not the expected types of impacts would likely occur in the river basins under study, an informal telephone survey of research groups was conducted. The survey covered county extension agents for a subset of those counties comprising the three river basins, and researchers at the

largest university in or near each river basin. The latter group included the following:

- Clemson University,
- University of Georgia,
- Louisiana State University, and
- Texas A&M University.

No chemical producers were located which were operating experimental cotton acreages in the three river basins.

Each researcher surveyed was first asked whether or not they were familiar with the boll weevil program and its components. If the response was negative, no further questions were posed. The rationale for this was that any attempt to familiarize the person with the program would necessarily bias the responses from that point on. Second, if a respondent was not at all familiar with the program, it would be impossible for that person to attribute impacts upon research to it. In the case of county extension agents, only 35 percent (7 of 20) of those contacted were aware of the program and its components. University research personnel, on the other hand, were much more aware of the program, with 100 percent (15 of 15) giving a positive response.

All those giving positive responses were then asked if they were conducting research of the types discussed previously, or any other research which, in their opinion, would be impacted by the programs. In all cases, there was no indication of conflict except in terms of funding considerations. There were no indications of physical impacts upon the ongoing research of those contacted. As there were no indications of impact, there was no need to continue questioning each researcher as to types and extent of impact.

It must be stressed that the survey conducted was relatively limited in scope, and was not intended to quantify dollar losses. This was due to the predictive nature of the assessment being conducted where only general information on the nature of potential impacts can be developed.

SOCIAL PERCEPTION

An informal survey was conducted over the three river basins to derive a profile of societal perceptions relative to the program. Ideally, this survey would have been of a much more formal nature and would have been targeted to a much larger cross section of area inhabitants. Due to delays incurred in receiving beltwide program definitions and in receiving information relative to the programs, such as insecticides to be used, formulations, acreages receiving applications, etc., time did not permit the conduct of a comprehensive survey. Instead, an informal survey of producer groups and Government personnel (notably county extension agents), was conducted. No private environmental protection groups were found in the area evaluated.

As was the case with the treatment of the analysis of potential research conflicts, no attempt was made to describe the beltwide boll weevil program alternatives to those unfamiliar with the program. To do so would have introduced a sizeable bias into the responses given. Those responding who were not familiar with the program were questioned no further. Of those contacted,only 52 percent were at all familiar with the program or its components (CIC, OPM, BWE). However, as was the case with those surveyed relative to reseach conflicts, the majority of those familiar with the program were research personnel. Those who were familiar with the program were concerned only with the technical and operational feasibility of beltwide applications of the alternative programs. All attempts to derive a profile of perceived environmental impacts were therefore unsuccessful.

Based upon the findings of the informal survey conducted, there appear to be very little awareness of the program or its component alternatives; hence, perception to date was essentially nonexistent. A finding such as this should not be construed to mean that area inhabitants perceived no adverse or beneficial impacts stemming from the program. It does imply, however, that area inhabitants need to be advised as to the nature of the program and control alternatives should a beltwide program be implemented.

SUMMARY AND CONCLUSIONS

This report comprises the ENET's environmental evaluation of the boll weevil control trial strategies during the 1978-1980 trial years and the environmental evaluation of the Beltwide Boll Weevil/Cotton Insect Management Programs. Three major control program alternatives are addressed: Current Insect Control (CIC), Optimum Pest Management, and Boll Weevil Eradication (the latter two represent OPM-I and OPM-BWE, respectively, for the beltwide evaluation).

The ENET's evaluation effort should meet the concern that agencies conduct their programs in ways which protect the Nation's ecological, cultural, and historic heritage as embodied in the intent of statutes, regulations, Executive Orders, and Secretary Memoranda on the subject. This evaluation embodies the recognition that the logic of control decisions must be based on very sound knowledge of (1) the crop protection chemicals and their potential hazard, (2) the patterns of transport throughout the environment and consequent exposure levels, (3) the effects of these calculated exposure levels upon biotic and abiotic interactions, and (4) the risk of these interactions upon sensitive environmental areas. The following presents the technical evaluation of the trial strategies and beltwide programs within the context of these four considerations.

Trials

The environmental evaluation for the trial areas utilized the methodology of BOLL-1, a local area evaluation model. Seven areas of impact (risk) were addressed with numerical indices of potential impact calculated for each. The seven areas of risk (offsite drift, human ingestion, research conflicts, endangered and threatened species, fish farms and hatcheries, wildlife, and aquatics) were combined into an overall index of impact for each of the trial

strategies. This overall index Q, is defined as the weighted sum of the normalized indices. The index is an expression of environmental risk and is scaled to fall between 0 (no effect) to 1000 (worst effect). The following Q values were calculated for the three trial years:

OVERALL INDICES OF TRIAL STRATEGIES

	Trial Years		
Strategy	1978	1979	1980
Q_{OPM}	257	346	329
Q_{CIC-MS}	37	138	164
$Q_{OPM-BWE}$	160	24	12
Q_{CIC-NC}	219	294	171

The major dimension of impact which affected the overall index was human ingestion which, in turn, was directly affected by offsite drift. As the magnitude of insecticide was changed (i.e., more or less acres treated), the overall index also increased or decreased.

The Q values of each control strategy in other areas were also calculated by simulating conditions in those trial areas where the boll weevil control strategy was not actually being tested.

These results indicated that the BWE strategy after the first year had the lowest overall index of impact in the trial areas. This was primarily attributed to the reduced amount of insecticide used which resulted in a low human ingestion index. However, the overall indices could all be considered low when compared to a maximum value of 1,000. All the trial strategies, therefore, were of relatively low risk to the environment.

The pesticide residue monitoring data gathered by APHIS in 1978, 1979, and 1980 likewise indicated that none of the strategies had a high potential for adverse environmental impact in the trial areas.

Beltwide Programs

The Environmental Evaluation of Pesticides (EEP) model was utilized to evaluate the environmental impact of the projected Beltwide Boll Weevil/Cotton Insect Management Programs. The evaluation consisted of a detailed analyses (including pesticide residue transport and distribution modeling) over three river basins, the Santee, Flint, and Red. A less detailed analysis over 12 additional river basins was also conducted (transport and distribution modeling was excluded). The 15 river basins were selected by the ENET to represent the river basin evaluation across the Cotton Belt.

Because of time delivery constraints, only the results of the three modeled river basins are presented in the ENET report itself. However, the evaluation of the additional 12 river basins indicate no significant changes to the results of this report and are included as Attachment M.

The beltwide evaluation was limited to major insecticides utilized in the three control strategies which were representative of four major categories of pesticides, i.e., organophosphates, carbamates, synthetic pyrethroids, and diflubenzuron, an insect growth regulator.

The CIC program projected the use of methyl parathion, methomyl, and permethrin over the Cotton Belt. There were no adverse effects expected in the three river basins with respect to nontarget agriculture; that is, there were no projected adverse effects upon livestock and poultry or upon crops. There were no projected significant acute or subacute impacts associated with any of the insecticides evaluated upon aquatic species. No effects were foreseen in terms

of adverse impact upon wildlife or human ingestion in any of the three river basins. The analysis showed that the very nature of the insecticides(e.g. rapidly degradable and nonlipophilic) negated such effects. With respect to endangered and threatened species, the only impact expected was a potential adverse effect in the southernmost portion of the Santee upon the State-listed threatened beetle species Myotrupes retuses. There were no expected impacts upon endangered and threatened species in either of the other two river basins.

The OPM program, defined as OPM-I beltwide, projected the use of the same three insecticides as for the CIC program, but they would be used in slightly lesser amounts over less total acreage. The results of the analyses were essentially the same as with the CIC program over all three river basins. However, given the lesser amounts of insecticides that would be applied, the degree of impacts would be lessened to a commensurate degree.

The BWE program, defined as OPM-BWE beltwide, projected the use of malathion, diflubenzuron, and azinphos-methyl. The beltwide evaluation of the OPM-BWE program was based only on the first year of boll weevil treatment within any given area, representing the highest insecticide exposure or worst-case condition. As with CIC and OPM-I, no significant adverse environmental impacts were projected in the three river basins for the OPM-BWE program. After the first year, EET Delphi estimates projected that less insecticides would be necessary for any given area in the OPM-BWE program. Consequently, the potential of environmental risk would be even further reduced.

There were no reports of expected impact in terms of research conflicts resulting from any of the three programs over any of the river basins studied. There existed a potential for research conflict with respect to the BWE program because of its requirement that all cotton in the area be included in the

program; however, no specific examples of potential impact were found via an informal survey of area researchers. In terms of social perception, a very low percentage of those persons questioned were aware of the program or its components and they were concerned only with the technical feasibility of the beltwide implementation of a program. This reflects the fact that the vast majority of those who are aware of the program are engaged in cotton production related research.

The evaluation revealed three potential areas of impact common to each program, all of which could be easily mitigated.

- Because of the toxicity of the program insecticides to honeybees, bee colonies next to cottonfields could suffer losses unless moved to a safe distance.

- Endangered and threatened species could be jeopardized by a beltwide program. One such State-listed threatened beetle species, Myotrupes retuses, was identified in the Santee river basin. Habitats for these identified species should be mapped to ensure that such habitats are not inadvertently sprayed.

- A worst-case scenario indicated that populations of some small aquatic organisms in farm ponds or streams adjacent to cottonfields could be affected after insecticide application, followed by excessive runoff from heavy rains. Because of the short-lived nature of the program insecticides, these aquatic populations should rapidly recover.

Based on the technical analyses that were performed which addressed the environmental effects of the three candidate strategies in the trial areas and selected

river basins (Santee, Flint, and Red), there were no substantial adverse environmental effects expected from the CIC, OPM-I, or OPM-BWE programs.

In conclusion, from an environmental risk standpoint, a reduction of pesticide use in any program reduces the potential risk of adverse effects and, thereby, has the tendency to improve the quality of the environment. The benefit of pesticide reduction is that the capacity of the environment to respond to the exposure levels of pesticides is also improved. This implies that any boll weevil program which reduces its total pesticide load in the environment has the tendency to improve the capacity of the environment to respond to insecticide pressure. This improved environmental capacity potential should be a major benefit in terms of human health, aesthetics, recreation, social cost, and so forth.

Although the beltwide evaluation indicated that a selected program may not cause significant adverse effects on the environment, there are at least 15 other prominent legislative Acts which mandate Federal Agencies to environmental conservation. These Acts address the protection, conservation, rehabilitation, or mitigation of the environmental resources of the Nation. Since any one of these legislative Acts, not to mention State and Federal regulatory actions, could impact the operation of any beltwide program, the ENET recommends that provisions be made to continue an environmental evaluation (not limited to pesticide residue monitoring) should a beltwide program be selected for implementation. Due to the extended time frame for completion of the beltwide program, a long-term environmental evaluation commitment should be made to track the selected program to its completion.

REFERENCES CITED

1. Rudd, R. L., and Genelly, R. E. 1956. Pesticides: Their Use and Toxicity in Relation to Wildlife. Game Bulletin No. 7. California Department of Fish and Game.

2. National Academy of Sciences, National Research Council. 1961. A Symposium of Pest Control and Wildlife Relationships. Pub. 897.

3. Division of Biology and Agriculture, National Research Council to the U.S. Department of Agriculture. May 1969. "Report of Committee on Persistent Pesticides."

4. National Academy of Sciences. February 1-3, 1966. Scientific Aspects of Pest Control—A Symposium. Washington, DC. Pub. 1402.

5. Agriculture Research Service, U.S. Department of Agriculture. July 1966. Pest Control by Chemical, Biological, Genetic, and Physical Means--A Symposium. ARS 33-1100. Fish and Wildlife Service, U.S. Department of the Interior, Special Scientific Report. October 1968. Organochlorine Pesticides in the Environment. Wildlife No. 119, Washington, DC.

6. National Academy of Sciences. 1975. Principles for Evaluating Chemicals in the Environment.

7. Carson, Rachael. 1964. Silent Spring. Fawcett Publications.

8. Mrak, Emil. December 1969. Report of the Secretary's Commission on Pesticides and Their Relationship to Environmental Health, Parts I and II. U.S. Department of Health, Education, and Welfare.

9. Council on Environmental Quality. May 1977. The President's Environmental Program--1977.

10. Secretary's Memorandum No. 1890 (Revised). 1979. USDA Program for Environmental Quality.

11. Nicholson, H. Johnson and Castore, C. H., Purdue University, Water Resources Research Center. March 1979. Quantitative Situational Analysis. Technical Report 120.

12. Environmental Protection Agency, Corvallis Environmental Research Laboratory. October 1978. Social Decision-Making for High Consequence, Low Probability Occurrences.

13. Lowrance, William W. Of Acceptable Risk, Science and the Determination of Safety.

14. Ketron, Inc. Rev. December 13, 1979. Guidelines for Risk/Benefit Hazard Assessment of Pest Control Programs. KTR 125-79.

15. Shaeffer, D. Lynn, Oak Ridge National Laboratory. August 1979. A Model Evaluation Methodology Applicable to Environmental Assessment Models. ORNL-5507.

16. Sievering, Herman and A. P. Hurter. October 1977. A Guide to Environmental Benefit Assessments in Economic Impact Studies. Illinois Institute of Natural Resources, IIEQ 77/32.

17. Sievering, Herman and A. P. Hurter. January 1979. Decision Analysis and Environmental Regulations. Illinois Institute of Natural Resources, Document No. 79/03.

18. Sheff, Rosalyn L. July 1979. Environmental Benefits Assessment in Economic Impact Studies: A Review. Illinois Institute of Natural Resources, Document No. 79/19.

19. Environmental Protection Agency, Office of Pesticide Programs, Office of Water and Hazardous Materials. January 1976. A Benefit-Cost System for Chemical Pesticides. EPA 540/9-76-001.

20. Office of Air, Land, and Water Use, Office of Research and Development, U.S. Environmental Protection Agency. August 1977. Identification and Specification of Inputs for Benefit-Cost Modeling of Pesticide Use.

21. National Academy of Sciences, National Research Council. 1977. Decision Making in the Environmental Protection Agency. Vol. II.

22. National Academy of Sciences, National Research Council. 1977. Environmental Monitoring. Vol. IV.

23. Staffa, J. A. 1978. Symposium on Risk/Benfit Decisions and the Public Health. Colorado Springs, Colorado.

24. Giles, Robert H. 1977. A System for Assessing Ecological Efforts of Large Area Pesticide Applications. Fianl Report to the Environmental Evaluation Staff.

25. Ketron, Inc. May 20, 1977. Final Report. A Methodology for the Evaluation of the Environmental Effects of the Boll Weevil Eradication and Optimal Pest Management Programs. KFR 118-77.

26. Ketron, Inc. October 21, 1977. A Model for the Evaluation of the Environmental Effects of Pesticides. Phase I Report. KFR 132-77.

27. Ketron, Inc. March 20, 1978. A Model for the Evaluation of the Environmental Effects of Pesticides. Phase II Report. KFR 165-78.

28. Ketron, Inc. March 31, 1978. A Handbook for a Model for the Evaluation of the Environmental Effects of Pesticides. Phase III Report. KFR 168-78.

29. Akesson, N. B. and W. E. Yates. 1964. Problems Relating to Application of Agricultural Chemicals and Resulting Drift Residues. Ann. Rev. Entom. 9:285-319.

30. Maas, W. and M. C. Kerssen. 1973. Drift Studies in ULV and Conventional Applications. Agricultural Aviation 15(2): 41-47, 50.

31. National Enforcement Investigations Center. 1976. Pesticide Use Observations in Leflore County, Mississippi. USEPA, Denver, Colorado. EPA-33/2-76-038.

32. Cooke, F. 1979. Current Cotton Insect Control Practices in Boll Weevil Infested States. Manuscript under Review.

33. Brazzel, J. November 1980. Revised Draft Boll Weevil Eradication Plan.

34. Agriculture Handbook 537. 1978. Predicting Rainfall Erosion Losses: A Guide to Conservation Planning. USDA-SEA, in cooperation with Purdue Agriculture Experiment Station.

35. USDA Soil Conservation Service. August 1972. National Engineering Handbook, Section 4: Hydraulogy.

36. Roach, E. R. 1973. The Effects of the Boll Weevil Eradication Experiment on Certain Wildlife Species. Unpublished MS Thesis, Mississippi State Universtiy. 54 pp.

37. Pouch, R. H. 1949. Audobon Land Bird Guide. Doubleday & Co., New York. 312 pp.

38. Odum, E. P. 1971. Fundamentals of Ecology, 3rd ed. W. B. Saunders, Phila. 574 pp.

39. Kendeigh, S. C. 1970. Energy Requirements for Existence in Relation to Size of Bird. Condor 72:60-65.

40. Schmidt-Neilson, K. 1972. How Animals Work. Cambridge University Press. 106 pp.

41. Bull, D. L. and G. W. Ivie. 1978. Fate of Diflubenzuron in Cotton, Soil, and Rotational Crops. J. Agric. Food Chem. 26 (3):515-520.

42. Wauchope, R. D. and R. A. Leonard. 1980. Maximum Pesticide Concentration in Agricultural Runoff: a Semiempirical Prediction Formula. J. Environmental Quality 9:665-672.

43. Wauchope, R. D. 1978. The Pesticide Content of Surface Water Draining from Agricultural Fields--a Review. J. Environmental Quality 7:459-472.

44. Thomson, W. T. 1980. Agricultural Chemicals--Book I, Insecticides. 236 pp.

45. Moffett, J. O., A. Stoner, L. N. Standifer, and A. L. Wardecker. 1978. Reducing Honey Bee Losses from Insecticides. American Bee Journal. 118(11):724-727.

46. Louisiana Water Quality Managment Plan. 1979. URS/Forest and Cotton, Inc.